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HEART & STROKE FOUNDATION
Canadian Partnership for Stroke Recovery

Chapter 15: Dysphagia rehabilitation

Abstract

Dysphagia is prominent across the continuum of stroke recovery and its presence is likely to result in pulmonary complications, particularly pneumonia, dehydration and poor nutrition. It is estimated that between 29 and 50 percent of acute stroke survivors are dysphasic. In this chapter, we describe techniques that are commonly used in the detection and assessment of dysphagia and aspiration. We also review the interventions used in the management of dysphagia including texture-modified diets, general dysphagia therapy programs, non-oral (enteral) feeding, medications, electrical stimulation, and physical/olfactory stimulation.

Jerome Iruthayarajah, MSc
Marcus Saikaley, BSc
Penny Welch-West, M.Cl.Sc.SLP
Norine Foley, MSc
Rosemary Martino, PhD
Marina Richardson, MSc
Rebecca Orenczuk, M.Cl.Sc.SLP
Robert Teasell, MD

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Key Points

There is conflicting evidence on the efficacy of dietary modifications to improve the pharyngeal phase, or respiratory infections.

Expiratory muscle training may be beneficial for improving the pharyngeal phase, but there is conflicting evidence for its ability to improve a dysphagia evaluation.

Gastronomy tube feeding may be more beneficial than nasogastric tubes for improving body composition and calorie consumption but not respiratory infections.

Balloon dilation therapy may be beneficial for improving dysphagia evaluations.

Thermal stimulation with NMES may be more beneficial than thermal stimulation alone for improving the pharyngeal phase, and dysphagia evaluations.

Suprahyoid, or suprahyoid with infrahyoid NMES may be beneficial for improving the pharyngeal phase, oral phase and dysphagia evaluations.

Infrahyoid NMES alone may not be beneficial for improving dysphagia related outcomes.

Pharyngeal electrical stimulation may not be beneficial for improving he pharyngeal phase, or dysphagia evaluations.

Contralesional anodal tDCS may be beneficial for improving dysphagia evaluations, but not respiratory infections.

The literature is mixed concerning the efficacy of high frequency rTMS for dysphagia and activities of daily living.

Bilateral rTMS may lead to greater improvements in dysphagia than unilateral rTMS.

Functional magnetic neuromuscular stimulation may improve dysphagia evaluations but does not appear to improve the pharyngeal phase.

Levetiracetam may be beneficial for improving dysphagia evaluations and the oral phase.

The may not be a difference in dysphagia evaluation outcomes between levetiracetam and levodopa with carbidopa.

There is conflicting evidence concerning acupunctures ability to improve dysphagia evaluation outcomes.

Modified Sackett Scale

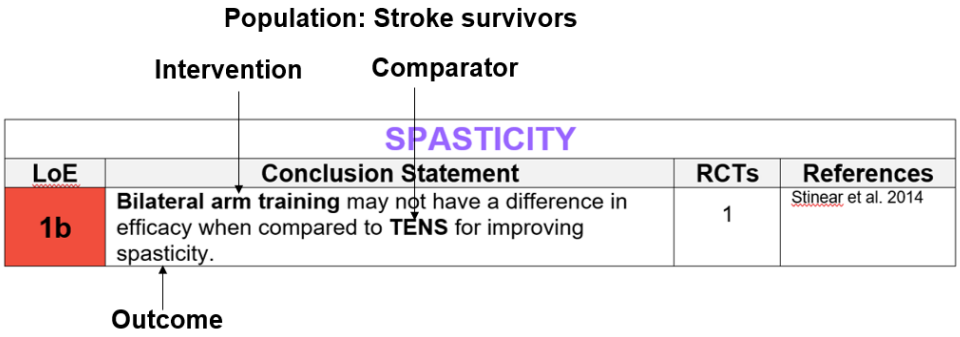
Level of evidence	Study design	Description
Level 1a	Randomized controlled trial (RCT)	More than 1 higher quality RCT (PEDro score ≥6).
Level 1b	RCT	1 higher quality RCT (PEDro score ≥6).
Level 2	RCT	Lower quality RCT (PEDro score <6).
	Prospective controlled trial (PCT)	PCT (not randomized).
	Cohort	Prospective longitudinal study using at least 2 similar groups with one exposed to a particular condition.
Level 3	Case Control	A retrospective study comparing conditions, including historical cohorts.
Level 4	Pre-Post	A prospective trial with a baseline measure, intervention, and a post-test using a single group of subjects.
	Post-test	A prospective post-test with two or more groups (intervention followed by post-test and no re-test or baseline measurement) using a single group of subjects
	Case Series	A retrospective study usually collecting variables from a chart review.
Level 5	Observational	Study using cross-sectional analysis to interpret relations. Expert opinion without explicit critical appraisal, or based on physiology, biomechanics or "first principles".
	Case Report	Pre-post or case series involving one subject.

New to the 19th edition of the Evidence-based Review of Stroke Rehabilitation

1) PICO conclusion statements

This edition of Chapter 15: Dysphagia rehabilitation synthesizes study results from only randomized controlled trials (RCTs), all levels of evidence (LoE) and conclusion statements are now presented in the Population Intervention Comparator Outcome (PICO) format.

For example:

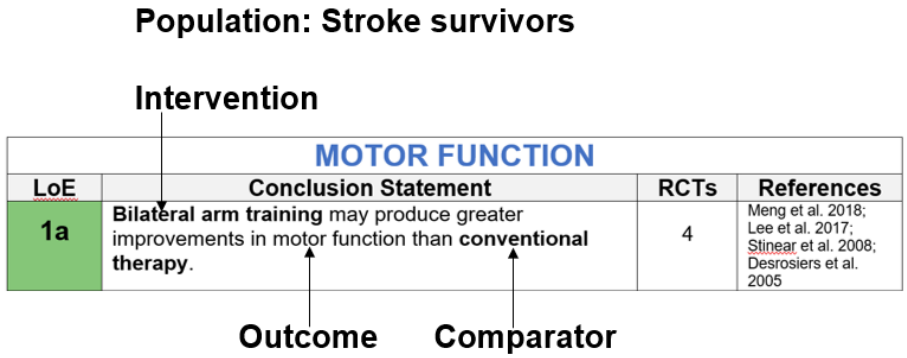


New to these statements is also the use of colours where the levels of evidence are written.

Red statements like above, indicate that the majority of study results when grouped together show no significant differences between intervention and comparator groups.

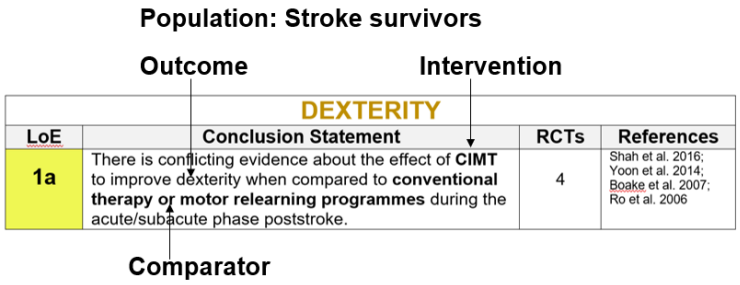
Green statements indicate that the majority of study results when grouped together show a significant between group difference in favour of the intervention group.

For example:



Yellow statements indicate that the study results when grouped together are mixed or conflicting, some studies show benefit in favour of the intervention group, while others show no difference between groups.

For example:



DEXTERITY			
LoE	Conclusion Statement	RCTs	References
1a	There is conflicting evidence about the effect of **CIMT** to improve dexterity when compared to **conventional therapy or motor relearning programmes** during the acute/subacute phase poststroke.	4	Shah et al. 2016; Yoon et al. 2014; Boake et al. 2007; Ro et al. 2006

2) Dysphagia rehabilitation outcome measures

Outcome measures were classified into the following broad categories:

Pharyngeal phase: These outcome measures assessed aspects of the pharyngeal phase of swallowing.

Esophageal phase: These outcome measures assessed aspects of the esophageal phase of swallowing.

Oral phase: These outcome measures assessed aspects of the oral phase of swallowing.

Dysphagia evaluation: These outcome measures assessed global tests of swallowing function, oral hygiene and eating behaviours in dysphagic individuals.

Respiratory infections: These outcome measures assessed respiratory sequelae of dysphagia including aspiration and pneumonia.

Activities of daily living: These outcome measures assessed performance and level of independence in various everyday tasks.

Stroke severity: These outcome measures assessed the severity of one's stroke through a global assessment of a multitude of deficits a stroke survivor may experience.

Lipid consumption: Outcome measure related to triglyceride body composition.

Calorie consumption: Assessed caloric intake and fluid intake.

Vitamin and mineral consumption: Assessed the consumption of vitamin or minerals.

Body composition: Different anthropometric measurements.

Plasma proteins: Outcomes that deal with circulating protein levels in a participant's blood.

Outcome measures that fit these categories are described in the next few pages.

Outcome Measure Definitions

Pharyngeal Phase

Aspiration-Penetration Scale (aka the 8-point aspiration-penetration): Is an 8-point equal appearing interval scale that is used to describe aspiration and penetration events. The aspiration score is determined by a trained clinician who observes whether or not a certain material entering the airway is expelled. The penetration score is likewise determined by a trained clinician who determines the how deep into the airway a certain material passes (Rosenbek et al. 1996).

Duration of Stage Transition: Is also known as the initiation of the pharyngeal phase and is the time when the hyoid begins its anterior excursion. More precisely put, it is the time from which the first barium passes the ramus of the mandible all the way until the beginning of maximum anterior hyoid excursion (Kim & McCollough 2007).

Episodes of Aspiration: Is a measure of how frequently a patient may aspirate within a given time period. Aspiration occurs when a patient ends up with food and/or fluid in their lungs. It typically occurs when a patient has dysphagia leading to food/liquid going down the trachea (Matsuse et al. 1996).

Higher Incidence of Aspiration: Is a term that describes the condition wherein a patient has food and/or liquid pass through the trachea and then enters the lungs. Patients who suffer from dysphagia typically have a higher incidence of this condition compared to patients without dysphagia (Morton et al. 2002).

Hyoid Elevation: Is the distance between the hyoid position when the bolus is held in the oral cavity and its point of maximal anterior and superior excursion during the swallowing action (Kendall & Leonard 2001).

Incidence of Aspiration: Is the amount of times a patient contracts aspiration within a given time period. Aspiration is a condition wherein food/liquid enters the lungs, greatly increasing the risk for a pulmonary infection and/or pneumonia (Marik 2001).

Inter Swallow Interval: Is the length of time between each swallow. It is calculated mathematically by figuring out the time (in seconds) it takes to complete a swallowing task divided by the total number of swallows (Alves et al. 2007).

Laryngeal Elevation: Is a measure that that determines the percentage maximal elevation of the larynx while a patient is swallowing. This number is typically given in a percent value. It is the vertical distance between the laryngeal resting position plus the superior maximal excursion position divided by the distance between the laryngeal resting position and the lower ramus of the mandible (Zhang et al. 2016).

Latency of Swallow: Is the amount of time that it takes for a patient to complete a swallowing action. Patients with dysphagia usually take a longer period of time to swallow compared to patients without dysphagia (Kobayashi et al. 1994).

Normalized Residue Rating Scale: is a measure designed to quantify the amount of residue present in the valleculae and the pyriform sinuses. It examines the amount of residue relative to the size of the valleculae of the participant. This method can more accurately

determine the risk of residue overflow for a particular individual because it is relative to the available pharyngeal space and the size of the individual (Pearson et al., 2013).

Pharyngeal Response: Is a reflex contraction that occurs at the back of the throat. It is most commonly evoked by touching the roof of the mouth, the back of the tongue, the area around the tonsils, the uvula and the back of the throat (Jadcherla et al. 2007).

Pharyngeal Transit Time (PTT): Is the amount of time it takes for the bolus to pass from the faucial arches, over the tongue and through the pyriform sinus into the esophagus. If PTT is increased (compared to a patient's age group), further testing is usually necessary (Nikhil et al. 2014).

Swallow Response Time (aka Swallow Speed): Is the time it takes for a swallowing motion to be initiated by a patient. For unaffected patients the average swallowing time is approximately 1 second, while for patients with dysphagia the average swallowing time is approximately 5-10 seconds (Karnell & Rogus 2005).

Esophageal Phase

Cricopharyngeal Opening Duration: Is the amount of time the cricocopharyngeus muscle stays open. This muscle is located at the top of the esophagus and helps open and close the esophagus. Patients with dysphagia typically have slow and/or incomplete closing of this muscle (Bua et al. 2015).

Esophageal Sphincter Function: There are two sphincters of the esophagus. The first is the upper esophageal sphincter, which allows the passage of solids and/or liquids. In patients with dysphagia there is improper/incomplete closing of the sphincter resulting in food and/or liquid potentially entering the trachea (Kahrilas et al. 1986). The second sphincter is the lower esophageal sphincter, whose primary function is to prevent acid and stomach contents from travelling backwards from the stomach. Typically, patients suffering from dysphagia have improper/incomplete closing of the sphincter resulting in digestive issues and/or pain (Patti et al. 1996).

Oral Phase

Oral Transit Time (OTT): Is a measure of the time taken for bolus transit in the oral cavity. This measure is typically evaluated radiographically by a trained clinician and involves a patient swallowing multiple times. Patients suffering from dysphagia usually have a longer oral transit time than those without dysphagia (Bolhuis et al. 2014).

Tongue Strength (Overall): Is usually measured using the Iowa Oral Performance Instrument (IOPI), which is a machine that can give a clinician the tongue strength of a patient in kPa (s). The average tongue strength of a healthy adult is 40-80 kPa, compared to the average tongue strength of a patient with dysphagia which is approximately 25kPa or less (Park et al. 2016).

Dysphagia Evaluation

Dysphagia Outcome Severity Scale (DOSS): Is a 7-point scale (0=severe dysphagia, 6=mild-no dysphagia) that is used to systematically measure the severity of dysphagia. Clinicians can then make recommendations for diet level, independence level and type of nutrition. Patients are assessed on three subsets: oral stage bolus transfer, pharyngeal stage retention and airway protection (O'Neil et al. 1999).

Dysphagia Severity Rating Scale (DSRS): Is a 7-point scale (0=normal swallowing, 6=severe dysphagia) that is used by trained clinicians to measure the severity of a patient's dysphagia. Evaluation occurs by having the clinician observe the patient swallowing in 3 different ways: without food/liquid, with liquid only and with food only (Waxman et al. 1990).

Functional Dysphagia Scale: Is a scale used to evaluate tracheal invasion by a food bolus or liquid. It is typically a 7-point scale wherein the higher a patient scores the poorer their swallowing function (0=very mild dysphagia, 6=severe dysphagia). This scale is typically administered by a trained clinician (Lee et al. 2016).

North-western Dysphagia Patients Checklist: is a measure that consists of 28 items, separated into 5 sections (medical history, behavioral, gross motor function, oromotor evaluation, swallowing). Each item is deemed 'safe' or 'unsafe', and the total score is calculated based on the number of items that were 'unsafe'. The measure has shown good reliability and validity in multiple languages (Bakhtiyari et al., 2018).

Repetitive Saliva Swallow Test: is a bedside swallowing exam designed to test a patient's ability to swallow saliva. Patients are repeatedly instructed to swallow their own saliva for 30 seconds. An individual would fail the exam should the number of swallows in 30 seconds be significantly less than the upper limits in a healthy, elderly population (Maeshima et al., 2013).

Mann Assessment of Swallowing Ability: consists of 24 items, with each score being converted into a weighted 5- or 10-point score, which are then summed for maximum of 200 points. Based on the score, an individual can be categorized into no abnormality (170-200), mild (149-169), moderate (141-148) or severe (≤ 140) (Chojin et al., 2017).

Dysphagia limit test: Is a way to assess not only for the presence of dysphagia, but is also an indicator for the severity. Water boluses are given at 1ml, 3ml, 5ml, 15ml and 20ml in ascending order. The 'dysphagia limit' is the maximum amount of water that can be swallowed without piecemeal deglutition (division of a large bolus into multiple successive swallows as opposed to one large one). Dysphagia is assessed based on the difference in an individual's limit to the lower limit in healthy aged matched controls (Ertekin, Aydoğdu & Yüceyar, 1996).

Australian therapy outcome measures – Swallowing Scale: is a standardized measure designed to comprehensively assess multiple aspects of dysphagia. The scale is split into four categories (impairment of structure/function, activity limitations, participant restriction and well-being) each of which is scored from 0-5, with higher scores indicated better outcomes within the respective categories (Perry, 2004).

Functional Oral Intake Scale (FOIS): Is a 7-point scale that evaluates how well a patient with dysphagia can consume liquids (1=no oral intake, 2=tube dependent with minimal/inconsistent oral intake, 3=tube supplements with consistent oral intake, 4=total oral intake of a single consistency, 5=total oral intake of multiple consistencies requiring special

preparation, 6=total oral intake with no special preparation, but must avoid specific foods or liquid items, 7=total oral intake with no restrictions). It is typically evaluated by having patients consume liquids under the supervision of trained clinician (Crary et al. 2005).

Degree of Dysphagia: is a non-standardized rating scale of the severity of dysphagia. It is graded from 1-4, with higher scores indicating more severe dysphagia (Ertekin et al., 2000).

Proportion of Patients Returned to a Normal Diet in 6mo: Is the proportion of a given subset of patients who end up returning to normal diet (oral feeding) (Jones et al. 1983).

Proportion of Patients with Oral Feeding Tolerability: Is the proportion of a given subset of patients who can tolerate a normal diet (oral feeding) (Jones et al. 1983).

Standardized Swallowing Assessment (SSA): Is an assessment that consists of three sub assessments: general assessment (consciousness, postural control etc.); ability to cough, saliva control, breathing and voice quality; and ability to sip water from a spoon plus ability to drink water from a glass. Patients who participate in these assessments are evaluated by a trained clinician (Xia et al. 2011).

Swallow Function Scoring System (SFSS): Is an assessment tool that measures the severity of dysphagia by having a trained clinician note the consistency of a liquid a patient can swallow without aspiration. This tool is a 7-point ordinal scale that ranges from 0 to 6 (0=severe dysphagia; no liquids tolerated, 6=no dysphagia; all liquids tolerated) (Coia et al. 1993).

Swallowing Function: Is a generic term that describes the different ways that a patient's swallowing ability can be evaluated. One of the ways this can be done is via a fiberoptic endoscopic evaluation of swallowing (FEES). This technique allows a trained clinician to insert a nasopharyngoscope into the patient and to measure multiple swallows via a video monitor. Another common technique is a videofluroscopic swallow study (VFSS). This technique allows a trained clinician to view a patient's swallowing function radiographically (Boesch & Deboer 2019).

Total Oral Transit Time: A combination of oral transit time and pharyngeal transit time (terms are defined above). Total Transit Time is usually greater in patients with dysphagia compared to patients without dysphagia (Shaw et al. 1995).

Videofluroscopic Swallowing Study (VFSS): Is a technique that is used to identify a patient's swallowing deficits in detail. A trained clinician uses radiography to view a patient's swallowing process in real time. This footage can then be played back to ensure a proper and adequate diagnosis. The videofluroscopic dysphagia scale (VDS) uses this study to grade various aspects of the swallow (Boesch & Deboer 2019).

Kubota Water Swallow Test: also referred simply as the water swallow test, has been modified several times since its inception. All procedures require an individual to take consecutive sips of water that (sometimes) increases in volume. Often, 3ml and/or 30ml are used as the volumetric amount. A score is given from 1-6 that grades the difficulty of swallow and any indication of airway obstruction (Horiguchi & Suzuki, 2011).

Volume Viscosity Swallow Test: is a tool for screening the safety and efficacy of swallowing. Participants are asked to perform a series of swallows of different volume (5-20ml) and viscosity (liquid, nectar and pudding). Any coughing, voice changes or a drop-in oxygen

saturation are indications of unsafe swallowing, and the graded viscosities/volumes can help determine which fluid condition is safest for the patient to swallow (Clave et al., 2008).

Actual Nutrition Status: is a rating scale used to classify the limitations an individual has with respect to swallowing. The scale is rated from 0 to 6, with 0 indicating full oral functioning and no limitations and 6 indicating tube feeding (Bülow et al., 2008).

Neurological examination of dysphagia: is an evaluation of a individual's neurological status of swallowing and other related functions. The measure looks for the presence or absence of head control, sitting balance, facial paralysis, gag and pharyngeal reflexes, in additions to palatal and tongue movements. Head control, sitting balance, facial paralysis and gag and pharyngeal reflexes are scored from 0 (nominal) to 1 (absent or dysfunctional). Palatal movement and tongue function are scored 0-2, with 0 referring again to nominal functioning (Umay et al., 2013).

Respiratory Infections

Incidence of Chest Infection: Is the amount of times a patient contracts a chest infection within a given time period. There are many different types of chest infections including: bronchitis, pneumonia and whooping cough (Sellars et al. 2007).

Pneumonia Frequency: Is a measure of how often a patient is diagnosed with pneumonia. Pneumonia is an infection wherein a patient's alveoli become inflamed and also fill with fluid. Once the alveoli fill with fluid then the rest of the lungs do as well (Schmidt et al. 1994).

Reduction in Ventilator Associated Pneumonia: Is the reduction of pneumonia (as seen above) but specifically pneumonia caused by a mechanical ventilator. Ventilator associated pneumonia (VAP) is commonly seen in critically ill patients (Chastre & Fagon 2002).

Higher Incidence of Aspiration Pneumonia: Is a term that describes a condition wherein a patient ends up contracting pneumonia due to aspiration of food and/or liquid. Patients who suffer from dysphagia typically have a higher incidence of this condition compared to patients without dysphagia (Marik 2001).

Activities of Daily Living

Barthel Index (BI): Is a measure of how well a stroke survivor can function independently and how well they can perform activities of daily living (ADL). The measure consists of a 10-item scale (e.g. feeding, grooming, dressing, bowel control). Possible total scores range from 0 to 100. (Park et al. 2018).

Functional Independence Measure (FIM): Is an 18-item outcome measure composed of both cognitive (5-items) and motor (13-items) subscales. Each item assesses the level of assistance required to complete an activity of daily living on a 7-point scale. The summation of all the item scores ranges from 18 to 126, with higher scores being indicative of greater functional independence. This measure has been shown to have excellent reliability and concurrent validity in its full form (Stineman et al. 1996).

Stroke Severity

Modified Rankin Scale (mRS): Is a measure of functional independence for stroke survivors. The measure contains 1 item. This item is an interview that lasts approximately 30-45 minutes and is done by a trained clinician. The clinician asks the patient questions about their overall health, their ease in carrying out ADLs (cooking, eating, dressing) and other factors about their life. At the end of the interview the patient is assessed on a 6-point scale (0=bedridden, needs assistance with basic ADLs, 5=functioning at the same level as prior to stroke). This measure has been shown to have good reliability and validity (Quinn et al. 2009; Wilson et al. 2002).

Lipid Consumption

Triglyceride levels: Is a measure of the amount of triglyceride in a patient's body. This measure is calculated by determining the concentration of the fat in the blood stream. The National Cholesterol Education Program (NCEP, 2002) sets a 'normal' triglyceride level below 150mg/dL.

Calorie Consumption

Proportion of Prescribed Feed Delivered: Is the amount of food a patient actually consumes. This is significant because patients with dysphagia tend to have a reduced appetite compared to patients without dysphagia (Johnson & Fischer 2004).

Total Fluid Intake: Is a measure of how many fluids a patient consumes in a given time period. Intake is usually measured daily, but measurement can vary across institutions. Additionally, intake can be measured in either millilitres (mL) or litres (L). It includes both prescribed fluid feed and water (Perrier et al. 2013).

Vitamin and Mineral Consumption

Calorie-Nitrogen Deficit: Is a measure of how much nitrogen a patient has in their body. Nitrogen is typically obtained from meat (both white and red), nuts, leafy greens, pomegranate and more. A deficit in nitrogen could be indicative of other nutritional deficits as well as suboptimal body functioning. Normal nitrogen levels for adults (18+) are between 7 to 20mg/dL (Pikosky et al. 2008).

Body Composition

Biceps Skinfold Thickness: Is fast way to roughly measure a patient's body fat percentage. This measure is a subsection of anthropometric measures (subscapular skinfold thickness, suprailiac skinfold thickness and bicep skinfold thickness. This assessment is done by a trained clinician using calipers. This assessment has good reliability and validity (Deurenberg, Pieters & Hautvast 1990).

Mid-Arm Muscle Circumference (MUAC): Is a measure that can help a clinician determine the nutritional status of a patient. A clinician measures the circumference of the right or left upper arm between the tip of the shoulder and the tip of the elbow. Lower measures are indicative of muscle wasting, which in turn can be indicative of lowered nutritional status and/or malnutrition (Landi et al. 2010).

Triceps Skinfold Thickness: Is fast way to roughly measure a patient's body fat percentage. This measure is a subsection of anthropometric measures (subscapular skinfold thickness, suprailiac skinfold thickness and bicep skinfold thickness. This assessment is done by a trained clinician using calipers. A normal skinfold thickness for adult men (18+) is 2.5mm and for adult women (18+) is 18.0mm. This assessment has good reliability and validity (Rolland-Cachera et al. 1997).

Weight Gain: Is the amount of weight a patient with dysphagia gains by the end of an intervention. It is significant because patients with dysphagia have a decreased appetite compared to those patients without dysphagia, which leads to significant weight loss (Korner et al. 2013).

Plasma Proteins

Albumin Levels: Is a protein that is manufactured naturally in the liver. Its purpose is to help keep fluid in a person's bloodstream so it does not leak into the surrounding tissues. Albumin can also help transport hormones vitamins and enzymes throughout the body. Normal albumin levels are typically 3.4-5.4g/dL, levels lower or higher than these numbers could be indicative of inflammation and/or infection (Gunduz et al. 2008).

Pre-Albumin: Is a protein that is mainly made by the liver and is mainly a building block to make other proteins. For adults (18+) of both sexes normal pre-albumin levels are 15 to 36mg/dL. Levels higher than these could be indicative of kidney disease, Hodgkins disease, iron deficiency, and other ailments (Beck & Rosenthal 2002).

Transferrin: is the principle protein in blood plasma that is responsible for binding iron, and transporting through the circulatory system. Transferrin levels in the blood can be decreased or increased as a result of many different conditions (Bartnikas, 2012).

Hemoglobin: is the protein within red blood cells that bind to and carry oxygen within the blood. Vitamin or nutrients deficiencies can lead to decreased hemoglobin levels.

Introduction

Dysphagia is defined as difficulty with swallowing and is a common complication of stroke. The incidence of dysphagia in acute stroke patients is highly variable with a review reporting it ranging from 8.1 to 80% (Takizawa et al. 2016). While others attribute the variability to different methods of screening: cursory screening (37% to 45%), clinical testing (51% to 55%), and instrumental testing (64% to 78%) (Martino et al. 2005). The presence of dysphagia can be identified on the basis of clinical or radiographic examinations, or both.

The presence of dysphagia in stroke survivors has been associated with increased mortality and morbidities such as malnutrition, dehydration and pulmonary compromise (Barer, 1989; Finestone et al., 1995; Gordon et al., 1987; Kidd et al., 1995; Schmidt et al., 1994; Sharma et al., 2001; Smithard et al., 1996; Teasell et al., 1994). Evidence indicates that detecting and managing dysphagia in acute stroke survivors improves outcomes such as reduced risk of pneumonia, length of hospital stays and overall healthcare expenditures (Smithard et al., 1996).

Aspiration following stroke, the most clinically significant symptom of dysphagia, has long been associated with pneumonia, sepsis and death. It has been reported that pneumonia was the second most common cause of death during the acute phase of a stroke, with up to 20% of individuals with stroke-related dysphagia dying during the first year post-stroke from aspiration pneumonia (Bounds et al., 1981; F. L. Silver et al., 1984). Steele found that the number of swallowing difficulties seen in stroke survivors was negatively associated with length of hospitalization (Catriona M. Steele, 2002). Detection of aspiration, both silent and audible, and subsequent adaptive management strategies are regarded as important in the prevention of pneumonia (Altman, 2012; Anderson et al., 2004; Arai et al., 1998; Horner & Massey, 1988; Horner et al., 1988; Jeri A. Logemann & Logemann, 1983; Teasell et al., 1996; Tobin, 1986; Veis & Logemann, 1985). Management of dysphagia largely focuses on strategies to avoid aspiration following stroke as well as improving patients' quality of life,

Normal Swallowing

Swallowing has four sequential coordinated phases: the oral preparatory phase, the oral propulsive phase, the pharyngeal phase and the esophageal phase. Each of the phases of a normal swallow is described below (Armstrong et al., 2013; Jean, 2001).

Table 1. The Four Phases of Normal Swallowing (Platt, 2001)

Phase	Characteristics
Oral Preparatory	Food in the oral cavity is manipulated, masticated, and mixed with saliva in preparation for swallowing. The back of the tongue controls the position of the food, preventing it from entering prematurely into the pharynx.
Oral (Propulsive)	The tongue transfers the bolus of food from anterior to posterior aspects of the oral cavity and to the pharynx, triggering the pharyngeal swallow.
Pharyngeal	Complex and coordinated movements of the tongue, pharyngeal musculature and structures propel the bolus into the esophagus, while protecting the airway.
Esophageal	Coordinated contractions of the muscles of the esophagus move the bolus through the esophagus towards the stomach.

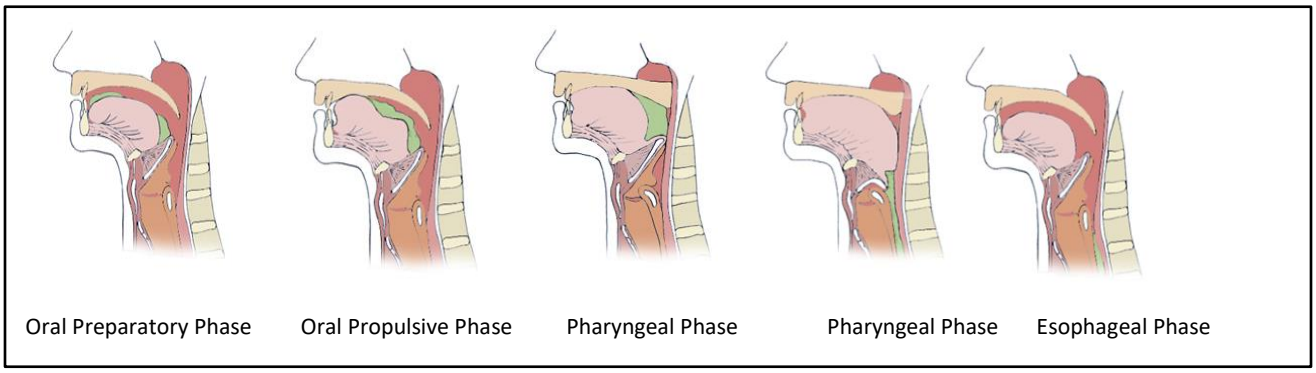


Figure 1: The phases of swallowing

Conclusions Regarding Normal Swallowing

- **There are four sequentially coordinated phases involved in normal swallowing; oral preparatory, oral propulsive, pharyngeal and esophageal.**

Pathophysiology of Dysphagia

Dysphagia post-stroke has long been attributed to oropharyngeal muscular dysfunction and incoordination, secondary to central nervous system loss of control. Brain stem lesions are commonly cited as having an association with the presence of dysphagia. However, it has also been suggested that lesions in specific cortical locations may be more common in patients with dysphagia or those with a risk of aspiration (Galovic et al., 2013; Momosaki et al., 2012). Furthermore, oral weakness of the facial, palatal and pharyngeal muscles can contribute to dysphagic symptomology (Jaradeh, 2006). Signs and symptoms of dysphagia include: choking on food, coughing during meals, drooling or loss of food from mouth, pocketing of food in cheeks, slow, effortful eating, difficulty when swallowing pills, avoiding food or fluids, complaining of food sticking in throat, problems swallowing, changes in vocal quality, weight loss, temperature fluctuations after eating, reflux or heartburn (Schmidt et al., 1994).

There is a wide range of pathophysiologic complications associated with dysphagia. Dysfunction related to the manifestation of dysphagia post-stroke is consistently reported. Specifically, complications in the pharyngeal phase of swallowing are highly prevalent. In a moderately high powered observational study, Kim et al. (2014) investigated the relationship between swallowing difficulties and lesion location. When compared, territorial anterior circulation infarcts were associated with oral phase dysfunction while territorial posterior circulation infarcts (TPI) and white matter disease resulted in complications in the pharyngeal phase of swallowing. Additionally, the incidence of penetration and aspiration was significantly increased in patients with TPI. Left or right hemisphere strokes as well as anterior lesions may also be related to the development of pharyngeal phase dysfunction (Robbins et al., 1993). Alternatively, cough flow in pulmonary dysfunction was investigated as an important protective mechanism in clearing the airway and avoiding aspiration in patients with dysphagia. Dysphagic patients were shown to have a significantly lower mean peak cough flow than either non-dysphagic patients or healthy controls (both statistically significant at $p<0.05$). Perhaps as a result, moderate penetration-aspiration scores were observed among the individuals with dysphagia (Y. Kimura et al., 2013).

The cortical mechanisms behind the development of dysphagia are complicated and widespread. Two studies explored functional neurological connectivity in relation to dysphagia (Li et al., 2014a; Li et al., 2014b). Results from both studies indicated a decrease in connectivity in relation to swallowing ability in stroke patients with dysphagia when compared to stroke patients without dysphagia and healthy controls. However, the authors suggested further research with broader inclusion criteria to investigate multiple lesion sites.

Overall, only studies with low power and quality have reported the pathophysiology of dysphagia post-stroke. Future research should be focussed on gaining valid evidence relating lesion location to dysphagia severity. This information may provide concrete links between location and dysfunction which will increase our understanding of this disorder and inform potential methods of treatment.

Conclusions Regarding the Pathophysiology of Dysphagia Post-Stroke

The prevalence of dysphagia in the pharyngeal phase of swallowing appears to be high. Functional disturbances may vary based on lesion location.

Decreased functional neurological connectivity may be associated with the presence of dysphagia and lead to complications in swallowing.

- **Dysphagia is characterized by reduced coordination of oropharyngeal muscles potentially due to a reduction of cortical connectivity which may have a negative impact on factors of pulmonary function. Furthermore, oral weakness of the facial, palatal and pharyngeal muscles can contribute to dysphagic symptomology.**

Aspiration Associated with Dysphagia

Aspiration is defined as "entry of material into the airway below the level of the true vocal cords". Since many stroke patients with dysphagia do not aspirate, the two terms are not synonymous, although they are closely associated. The diagnosis of aspiration should be suspected when the stroke survivor has any of the following: a subjective complaint of trouble swallowing, an abnormal chest x-ray, congested voice quality, or a delay in voluntary initiation of the swallow reflex and coughing during or after swallowing (Horner & Massey, 1988). Diagnosis may initially be established through clinical assessment involving an oral motor examination followed by the introduction of one or several teaspoons of water. If patients are able to successfully swallow this minimal amount of fluid, a small cup of water may be carefully introduced. More detailed clinical assessment of swallowing function such as that completed by a speech language pathologist are described elsewhere (Shaw et al., 2004; Smithard et al., 1996). While all stroke patients are potential aspirators, there are certain identifiable risk factors that have been recognized as greatly increasing the likelihood of aspiration. These clinical risk factors are listed in Table 2.

Table 2. Risk Factors for Aspiration Post-Stroke

- Brainstem Stroke
- Difficulty swallowing oral secretions
- Coughing/throat clearing or wet, gurgly voice quality after swallowing water
- Choking more than once while drinking 50 ml of water
- Weak voice and cough
- Wet-hoarse voice quality
- Recurrent lower respiratory infections
- Low-grade fever or leukocytosis
- Auscultatory evidence of lower lobe congestion
- Immunocompromised state

In one retrospective study, the association between the location of post-swallow residue and penetration-aspiration following a subsequent clearing swallow was examined. Results indicated that post-swallow vallecular residue, but not pyriform sinus residue, was significantly associated with penetration-aspiration on subsequent clearing swallows. The authors stated that in order to investigate post-swallow residue, analysis was limited to cases in which multiple swallows were used to clear a single bolus. Therefore, results were not extrapolated to patients unable to initiate multiple swallows in response to post-swallow residue. Additionally, extended monitoring of the swallow sequence regarding safety in the context of delayed post-swallow aspiration was not examined due to considerations of the radiation exposure from videofluoroscopy. It was suggested that both videofluoroscopy and endoscopy be used in future studies to avoid this concern (Molfenter & Steele, 2013).

Conclusions Regarding Aspiration Associated with Dysphagia

There is limited level 4 evidence suggesting that the presence of post-swallow vallecular residue (over residue in the pyriform sinuses) may result in a greater risk of penetration-aspiration.

- **There are many risk factors indicative of aspiration post-stroke.**
- **Swallow residue may be related to penetration-aspiration and swallow safety. Further research is required to determine the validity of this association.**

Silent Aspiration Post-Stroke

In addition to overt signs of aspiration, such as chocking or coughing, a substantial number of patients experience silent aspiration, highlighting the importance of using VMBS studies. "Silent aspiration" is defined as "penetration of food (or liquid) below the level of the true vocal cords, without cough or any outward sign of difficulty" (Linden & Siebens, 1983). It is further complicated by a “lack of strong coughing or throat clearing when foreign materials are aspirated into the subglottic area” (J. Y. Lee et al., 2014). Detailed clinical swallowing assessments were shown to under-diagnose or miss these cases of aspiration (Horner & Massey, 1988; Horner et al., 1988; Splaingard et al., 1988; Terre & Mearin, 2006). In particular, the presence or absence of a gag reflex failed to distinguish aspirating from non-aspirating stroke patients (Horner & Massey, 1988; Horner et al., 1988; Splaingard et al., 1988). This is an important clinical point as presence or absence of a gag response has unfortunately been used historically as an evaluative tool in determine swallowing function in some clinical contexts. However, two studies found the use of the Simplified Cough Test (SCT) to be a valuable tool in screening for silent aspiration in dysphagic patients (J. Y. Lee et al., 2014; Sato et al., 2012).

Lee et al. (2014) found the SCT to have 87.1% sensitivity and 66.7% specificity for detecting silent aspiration. Similarly, Sato et al. (2012) found the test to have 81% sensitivity and 65% specificity. The SCT, however, has a high rate of false positive and would be best used in combination with other screening tests such as the 5ml water test and cervical auscultation (J. Y. Lee et al., 2014; Sato et al., 2012). Silent aspirators were considered to be at increased risk of developing complications. Since the condition was not diagnosed, precautions to decrease aspiration risk such as diet modifications, positioning or changes to the feeding approach would often not be employed. Silent aspiration should be suspected in the stroke patient with recurrent lower respiratory infections, chronic congestion, low-grade fever or leukocytosis (Muller-Lissner et al., 1982). Clinical markers of silent aspiration may include a weak voice or cough or a wet-hoarse quality after swallowing.

Incidence of Aspiration Post-Stroke

Major complications associated with dysphagia can be related to the evolution of aspiration. Pneumonia, recurrent cough, choking and alterations of diet and fluid intake lead to compromised nutrition and hydration. These factors may lead to decreased quality of life and social isolation (D. L. Cohen et al., 2016). For these reasons, an early diagnosis of aspiration is important to avoid recurrent and alternative complications as well as improve recovery potential. Several studies have estimated the incidence of aspiration and silent aspiration post-stroke using a combination of clinical and radiographic techniques, discussion of these will follow.

The non-RCT studies included used a variety of clinical swallowing evaluations and the videofluoroscopic modified barium swallow (VMBS) study to identify aspiration. The incidence of aspiration identified using VMBS studies ranged from 16% (Smithard et al., 1996) to 51% (Horner et al., 1988). The incidence of silent aspiration was reported in four studies and ranged from 8.3% (Kidd et al., 1995) to 27% (Horner et al., 1988).

There is conflicting evidence of the reliability of the VMBS and bedside clinical evaluations used in the studies above. Splaingard et al. (1988) noted that while the identification of aspiration by VMBS is debatable, independent bedside evaluation underestimates its incidence in post-stroke patients. This moderately high powered study found that 40% of patients aspirated according to VMBS study versus the identification of 42% of proven aspirators by bedside evaluation. Additionally, the authors highlight that bedside evaluation was unable to detect silent aspiration. This finding was supported by another study in which VMBS consistently confirmed dysphagia and aspiration (M. Y. Chen et al., 1990). Contrary to these findings, the reliability of VMBS was called into question by another moderately high powered study. Bedside assessment of swallowing was useful in identifying patients at risk of developing complications including aspiration associated with dysphagia, while VMBS did not add sufficient value to this risk profile (Smithard et al., 1996). However, only 94 of the 121 total patients sampled were tested with the VMBS study. This reduced sample size may have led to the reduction of observed validity. Mann et al. (1999) compared a clinical exam and videofluoroscopy administered at three and 10 days post-stroke, respectively. Their results suggest that either aspiration is transient or that the clinical exam more accurately identified aspirators. Further research is required to evaluate the clinical effectiveness of both of these methods, and the potential effectiveness of their use together.

Early identification of the risk of dysphagia and aspiration among stroke survivors is essential to ensure proper treatment, prevention of subsequent complications and the application of correct diagnostic methods (S.K. Daniels et al., 1998). Chen et al. (1990) established that

videofluoroscopy can be used to assist with feeding recommendations through the definition of location and severity of oropharyngeal abnormalities. A number of the studies attempted to identify specific factors involved in the recognition of aspiration. Identified predictors included: presence of dysphonia, weak volitional cough and observed cough before/during/following swallow, delayed oral transit, delayed or absent swallow reflex, presence of penetration, soft palate dysfunction, facial hypesthesia, reduced peristalsis and respiratory tract infection (S.K. Daniels et al., 1998; Horner et al., 1988; Kidd et al., 1995; H. Kim et al., 2000; Mann et al., 1999).

Conclusions Regarding the Incidence of Aspiration and Silent Aspiration Post-Stroke

- **The incidence of aspiration in the acute phase of stroke varies from 16% to 52%. Silent aspiration occurs in 8% to 27% of acute stroke patients. Of identified aspirators, 20% to 67% developed silent aspiration.**
- **Factors indicative of the development of aspiration include: a delayed swallow reflex, reduced peristalsis, respiratory tract infection, abnormal volitional coughing and cough with swallow, dysphonia, soft palate dysfunction, and facial hypesthesia.**
- **Tested factors that may not be predictive of aspiration include: poor oral motility and bedside evaluations (which were associated with the identification of non-aspirators).**
- **While silent aspiration shows a lower incidence among acute stroke patients than aspiration, both are prevalent and reliably identified. Further research is required to identify viable treatment options.**

Incidence of Dysphagia Post-Stroke

Incidence of Dysphagia in the Acute Phase of Stroke

The initial diagnosis of dysphagia is a critical first step in treatment. Furthermore, the identification of indicators of dysphagia will help to focus efforts in dysphagia management. There are a wide variety of assessments used to evaluate dysphagia after stroke.

The studies reviewed assessed swallowing function in the acute phase of stroke using both clinical methods and videofluoroscopic examinations. Among these studies, the incidence of dysphagia ranged from 3.5% (Kuptniratsaikul et al., 2013) to 65% (S.K. Daniels et al., 1998). Based on their ability to swallow 10mL of water from a cup, Barer (1989) found that by six months only 0.4% of patients remained dysphagic from an initial proportion of 29%. However, this study excluded patients who were unable to swallow tablets on admission, which may have lowered the overall incidence rate. Alternatively, a very high powered study by Smithard et al. (2007) found that among 1288 acute stroke patients, the incidence of dysphagia was 44%. The authors concluded that dysphagia during the acute phase of stroke is associated with poor outcome in the subsequent year (particularly at three months), and over a five-year period results in an increase in the rate of institutionalization. These findings may have been skewed based on a failure to assess all patients before the one-week cut-off. Therefore, some cases of transient dysphagia resulting from less severe stroke may have been missed.

A few of the non-RCT studies included results suggesting an association between indicators of dysphagia and its incidence. Those that increased the incidence of dysphagia were: higher age,

diabetes, brainstem stroke, lower Canadian Neurological Scale score and a lower level of consciousness (Flowers et al., 2011). Additionally, one study found a significant association between previous history of stroke and incidence of dysphagia (Mansueto Mourão et al., 2016) The region of stroke may also affect the incidence of dysphagia. A meta-analysis concluded that within the infra-tentorium, incidence of dysphagia was found to be 0% in the cerebellum, 6% in the midbrain, 43% in the pons, 40% in the medial medulla and 57% in the lateral medulla. An increased risk of dysphagia was associated with legions in the pontine, medial medullary and lateral medullary regions (Flowers et al., 2011).

Conclusions Regarding the Incidence of Dysphagia in the Acute Phase of Stroke

- **The incidence of dysphagia appears to be quite variable following acute stroke with between 3.5% and 65% of patients affected, depending on the sample studied and the method of assessment used.**
- **Age, diabetes, neurological status, and lesion location may be associated with an increase in the rate of dysphagia.**

Prognostic Indicators of Dysphagia Post-Stroke

Following the identification of dysphagia as a post-stroke complication, the ability to recognize prognostic indicators can improve dysphagia research methodologies and treatment (Kumar et al., 2014). Additionally, this knowledge allows speech language pathologists to more effectively communicate treatment and recovery outcomes to patients and family members (McMicken & Muzzy, 2009).

One high powered retrospective review attempted to identify important prognostic variables affecting dysphagia recovery post-stroke (Kumar et al., 2014). Dysphagia at discharge was significantly associated with the presence of dysarthria, aspiration, intubation and bi-hemispheric infarcts, National Institutes of Health Stroke Scale scores ≥12 and level of consciousness. However, there were a number of limitations to this study. Patient records did not include detailed data on clinical deterioration or other complications prior to discharge, standardized swallowing tools were not used, follow-up was not conducted at predefined time points and there was a sex imbalance. Necessary adjustments were made in the analysis and the authors concluded that their final multivariate model was valid in the prediction of major clinical predictors influencing dysphagia recovery.

Conclusions Regarding Prognostic Indicators of Dysphagia Post-Stroke

- **There is level 3 evidence that potential prognostic indicators of dysphagia include: the presence of dysarthria, dysphonia and aspiration, abnormal cough and cough after swallow, National Institute of Health Stroke Scale scores ≥12, level of consciousness assessment, intubation and bi-hemispheric infarcts, cognitive dysfunction, disuse syndrome, fever and length of hospital stay (inversely related).**

Pneumonia and Aspiration Post-Stroke

Those patients who aspirate over 10% of the test bolus or who have severe oral and/or pharyngeal motility problems on VMBS studies are considered at high risk for pneumonia (Jeri A. Logemann & Logemann, 1983; Milazzo et al., 1989). In many cases, it is difficult to practically assess whether 10% or more of the test bolus has been aspirated. Nevertheless, the degree of aspiration seen on VMBS study is a critical determinant of patient management. Predicting whether a patient will develop pneumonia post-aspiration is, to some extent, dependent on other factors such as the immune state or general health of the stroke patient. Sellars et al. (2007) prospectively evaluated 412 stroke patients for up to 3 months following stroke. Over this period, there were 160 cases of either confirmed or suspected pneumonias. Independent predictors of pneumonia were age >65 years, dysarthria or no speech due to aphasia, a modified Rankin Scale score ≥4, an Abbreviated Mental Test score <8, and failure on the water swallow test. The presence of 2 or more of these risk factors carried 90.9% sensitivity and 75.6% specificity for the development of pneumonia.

The importance of the diagnosis and management of aspiration post stroke has been driven by the purportedly causal relationship between aspiration and pneumonia (Brown & Glassenberg, 1973; Hannig et al., 1989; Holas et al., 1994; Johnson et al., 1993).In turn, mortality following a stroke as a consequence of pneumonia (presumably due to aspiration) has been reported as high as 3% within the first 3 months (Kidd et al., 1995) and 6% within the first year (Hannig et al., 1989). Aspiration pneumonia has therefore been regarded as important due to its significant contribution to morbidity and mortality (Arms et al., 1974; Gordon et al., 1987; Hannig et al., 1989; Johnson et al., 1993; Jeri A. Logemann & Logemann, 1983; F. L. Silver et al., 1984; Veis & Logemann, 1985).

Aspiration alone is not sufficient to cause pneumonia. Aspiration of small amounts of saliva occurs during sleep in almost half of normal subjects (Finegold, 1991; Huxley et al., 1978). Aspiration pneumonia is thought to occur when the lung's natural defences are overwhelmed when excessive and/or toxic gastric contents are aspirated, leading to a localized infection or a chemical pneumonitis. Factors associated with an increased risk of aspiration pneumonia include: dysphagia related factors due to stroke (see Table 3.), as well as reduced level of consciousness, a tracheostomy, gastric reflux (Satou et al., 2013) or emesis, nasogastric tubes (due to mechanical interference with the cardiac sphincter), and a compromised immune system (Finegold, 1991). However, it remains uncertain to what degree the aspiration of colonized oropharyngeal contents contributes to pneumonia (Langdon et al., 2009).

Table 3. Factors more likely to be associated with diagnosis of aspiration pneumonia following stroke

- Brainstem stroke
- Aspiration on VMBS (risk greater if aspirates over 10% of barium laced test material)
- Aspiration of thick fluids or solids
- Slower pharyngeal transit time on VMBS

Defining Aspiration Pneumonia

Clinical criteria for aspiration pneumonia across studies have proven to be variable. Obviously, the criterion used for defining pneumonia influences its incidence. Much of the variability in incidence of aspiration among studies can be accounted for by differences in the inclusion

criteria for the diagnosis of pneumonia. Table 4 illustrates several criteria used to define aspiration pneumonia post-stroke.

Table 4. Criteria for Defining Pneumonia in Stroke

Author (Year) Country Study design (PEDro Score if RCT)	Criteria
Johnson et al. (1993) USA No Score	Aspiration pneumonia was defined by either segmental consolidation or infiltrate on chest x-ray or clinical diagnosis which included an episode of respiratory difficulty with segmental moist rales on auscultation and two other symptoms including temp >100 °F, WBC >10,000 or hypoxia.
DePippo et al. (1994) USA RCT (5)	Pneumonia was diagnosed by a positive chest x-ray or the presence of at least three of the following: temp > 100 °F, drop in PO2 > 10 torr, presence of WBC in sputum and/or positive sputum culture for pathogen.
Holas et al. (1994) USA No Score	Pneumonia was diagnosed by a positive chest x-ray or the presence of at least three of the following: temp > 100 °F, drop in PO2 > 10 torr, presence of WBC in sputum and/or positive sputum culture for pathogen.
Kidd et al. (1995) UK No Score	Diagnosis of pneumonia was based on the production of sputum in conjunction with the development of crackles on auscultation, with or without the presence of fever or leucocytosis.
Smithard et al. (1996) UK No Score	Chest infection was diagnosed on the presence of at least two of the following: tachypnea (> 22/min), tachycardia, aspiratory crackles, bronchial breathing or antibiotic usage.
Teasell et al. (1996) Canada No Score	The criteria for pneumonia included radiological evidence of consolidation, and at least one other clinical feature including granulocytosis, temp >38°C and/or shortness of breath.
Dziewas et al. (2008) Germany No Score	Pneumonia was diagnosed on the basis of 3 of the following indicators: temp >38°C, productive cough with purulent sputum, abnormal respiratory exam including tachypnea, (> 22 breaths/min), tachycardia, inspiratory crackles, bronchial breathing, abnormal chest x-ray, arterial hypoxemia (PO^2 < 9.3 kPa) and a positive gram stain.
Carnaby et al. (2006) USA RCT (8)	Pneumonia was diagnosed on the basis of 3 of the following indicators: temp >38°C, productive cough, abnormal respiratory exam including tachypnea, (> 22 breaths/min), tachycardia, inspiratory crackles, bronchial breathing, abnormal chest x-ray, arterial hypoxemia (PO^2 < 9.3 kPa), culture of a relevant pathogen; positive chest radiography.

Conclusions Regarding Criteria for Defining Pneumonia in Stroke

- **Criteria that may be most useful in the identification of pneumonia include: abnormal chest x-ray, temperature >100°F, WBC >10,000, arterial hypoxemia (PO_2 <9.3kPa), PO_2 >10torr, production of purulent sputum, crackles on auscultation, tachypnea >22 breaths/min, tachycardia, bronchial breathing.**
- **Studies included required affirmative outcomes on two or three of these indicative measures for a positive diagnosis of pneumonia.**
- **There is a wide range of criteria for the diagnosis of pneumonia post-stroke. More accurate results may come from the use of multiple measures.**

Relationship between Pneumonia and Dysphagia/Aspiration

A relationship between pneumonia and dysphagia/aspiration has been reasonably well established despite variability among studies. Nakajoh et al. (2000) have suggested that attenuated cough reflexes also increase a patient's risk of pneumonia. The incidence of pneumonia among dysphagic, bedridden patients who had experienced a stroke at least six months prior was 9/14 (63%). In these cases, the latency of the swallowing response, assessed by EMG activity and direct observation, was greater than 20 seconds. In contrast, the latency of response was less than four seconds among patients without dysphagia. The association between pneumonia and both dysphagia and aspiration was examined among a series of studies using odds ratios. The results are presented in Tables 5 and 6 and graphically in figures 2 and 3*. In all cases the incidence of pneumonia was higher among patients with dysphagia and/or aspiration.

Table 5. Relationship Between Dysphagia and Pneumonia

Author, Year	Incidence of Pneumonia Among Patients with and without Dysphagia	OR (95% CI, fixed effects model)
Gordon et al. (1987)	7/37 vs. 4/50	2.63 (0.72 to 9.96)
De Pippo et al. (1994)	10/82 vs. 1/57	7.78 (0.97 to 62.6)
Gottlieb et al. (1996)	9/50 vs. 9/130	2.95 (1.10 to 7.94)
Smithard et al. (1996)	20/60 vs. 9/57	2.67 (1.09 to 6.50)
Reynolds et al. (1998)	18/69 vs. 3/33	3.53 (0.96 to 12.99)
Teasell et al. (2002)	5/11 vs. 0/9	-
Falsetti et al. (2009)	8/62 vs. 1/89	13.04 (1.59 to 107.14)
Combined estimate	**70/398 vs. 34/398**	**2.28 (1.44 to 3.61)**

Table 6. Relationship Between Aspiration and Pneumonia

Author, Year	Incidence of Pneumonia Among Patients with and without Aspiration	OR (95% CI, fixed effects model)
Holas et al. (1994)	8/61 vs. 1/53	7.85 (0.95 to 65)
Schmidt et al. (1994)	5/26 vs. 1/33	7.62 (0.83 to 70)
Kidd et al. (1995)	17/25 vs. 2/35	35.06 (6.69 to 184)
Smithard et al. (1996)	7/20 vs. 12/74	2.78 (0.92 to 8.42)
Teasell et al. (1996)	10/84 vs. 2/357	24 (5.15 to 112)
Reynolds et al. (1998)	12/35 vs. 9/68	3.53 (0.87 to 16.5)
Ding & Logemann (2000)	61/175 vs. 40/203	1.88 (1.18 to 2.99)
Meng et al. (2000)	3/7 vs. 0/13	21 (0.90 to 490)
Lim et al. (2001)	5/26 vs. 0/24	12.53 (0.65 to 240)
Combined estimate	**128/468 vs. 67/850**	**6.53 (2.91 to 14.64)**

Discussion

From the pooled results presented in the figures above, the presence of aspiration was associated with a 4.45-fold increased risk of pneumonia while dysphagia (with or without aspiration) was associated with a 3.07-fold increase in pneumonia. All of the included studies found that dysphagia and aspiration result in an increased risk of pneumonia. The decreased oral intake associated with these complications can lead to nutritional deficiency and a depressed immune system. The inability of the host response to infection can subsequently lead to a downward spiral of worsening nutritional status and increased dysphagia severity (Veldee & Peth, 1992). Pneumonia can also result in an overall increase in hospital length of stay, higher cost and increased mortality (Reynolds et al., 1998).

A number of methods for the reduction in frequency of pneumonia have been reported. A water swallowing test to assess risk of chest infection should be followed by a modified diet consistency, nasogastric tube feeding or intravenous fluids, for those that fail the drinking test (Gordon et al., 1987; Gottlieb et al., 1996). Both bedside swallowing assessment and videofluoroscopy are predictive of increased risk of pneumonia. These tests provide information on different clinical variables and as such complement each other when used together. Patients recognized as at high risk of pneumonia, including those with large cortical strokes and/or impaired consciousness, should be administered these tests in combination to increase the yield of patients identified as at risk with oral feeding. Earlier identification of the risks associated with feeding in the presence of dysphagia allows precautionary measures to be taken including dietary modification and teaching of compensatory swallowing techniques that may reduce the risk of development of pneumonia in post-stroke patients with dysphagia (Reynolds et al., 1998). Between the relative datedness and the small to moderate sample sizes of the studies

included in both meta-analyses above, there is a need for updated research on the relationship between aspiration and dysphagia and subsequent pneumonia in larger patient populations. However, there is sufficient evidence to suggest that both these factors may increase the risk of pneumonia in stroke survivors.

Conclusions Regarding the Relationship between Aspiration and Pneumonia

- **There is level 1a evidence that dysphagia and aspiration may both be associated with an increased risk of developing pneumonia.**
- **This association appears to be proportional to the severity of aspiration.**
- **The risk of developing pneumonia increases in patients with dysphagia and aspiration.**

Incidence and Development of Pneumonia

The development of pneumonia has been widely established in the literature as a result of secretions colonized with pathogenic bacteria entering the pulmonary system, through aspiration or an alternative mechanism, in high enough concentrations to overcome the immune response (Langdon et al., 2009; Sellars et al., 2007). However, aspiration pneumonia is a multifaceted occurrence and many factors have been shown to predict its presence (Langdon et al., 2009). Gram-negative bacilli are the most common micro-organisms responsible for the development of aspiration pneumonia. Individuals with impaired swallow, especially stroke patients with dysphagia, are at increased risk of aspirating substances containing these harmful bacteria and therefore the rate of pneumonia in this population is increased (Md. Rashed Alam et al., 2014).

Pneumonia has been linked to an increase in length of hospital stay and mortality rate (Alsumrain et al., 2013; Anna Miles et al., 2014). A number of the studies examine factors involved in the development of pneumonia and avenues for the management of this comorbidity. A major cause of aspiration-pneumonia is the presence of bacteria in the oral cavity. Langdon et al. (2009) found that stroke patients requiring nutritional intake by nasogastric tube feeding were at increased risk of pneumonia compared to orally fed patients. This was perhaps due to an increase in aspiration of bacterial laden secretions or refluxed material. Intubation tubes used in stroke populations can further introduce bacteria into the lungs from the oral cavity. The authors suggest modifiable aspects of stroke treatment to better manage dysphagia and the development of pneumonia include measures to prevent reflux and stringent oral care.

Oral hygiene in post-stroke management is a significant risk factor that is largely overlooked. Providing adequate oral care and maintaining good oral hygiene is extremely important in acute stroke populations, as individuals are often unable to perform these activities on their own due to physical weakness, loss of full function in one hand, cognitive issues, reduce frequency in seeing dental professionals following stroke) (B. Clayton, 2012). The oral cavity is host to organisms suspected to be responsible for aspiration related pneumonia. The bacteria associated with periodontal diseases, including gingivitis and periodontitis, the presences of dental plaque, calculus as well as dental caries/decayed teeth are linked to chronic infection and inflammatory responses by the body. Proteins such as cytokines, which originate in the periodontal tissue and travel via the bloodstream to the lungs, may contribute to respiratory

inflammation and infection (B. Clayton, 2012; Tran & Mannen, 2009). Porphyromonus gingivalis (P. gingivalis), Streptococcus sobrinus (S. sobrinus) in dental plaque and Staphylococcus aureus (S. aureus) in saliva are reported to be higher in patients with aspiration pneumonia (Terpenning et al., 2001). The inability to clear food matter effectively in post-stroke populations can be largely due to the presence of xerostomia, or dryness of mouth. This hinders the ability to chew, swallow and speak properly, all of which are essential functions of saliva. When saliva becomes thick, ropey and less abundant, it accumulates more bacteria and microorgansisms that can be easily aspirated (B. Clayton, 2012).

Among patients with spontaneous intracerebral hemorrhage (sICH), significant predictors for the development of pneumonia include: mechanical ventilation, tube feeding, dysphagia and tracheostomy (Alsumrain et al., 2013). Mechanical ventilation leads to ventilator-associated pneumonia in 9% to 27% of patients due to aspiration of oropharyngeal pathogens or penetration of bacteria past the endotracheal tube cuff (Chastre & Fagon, 2002). Pneumonia developed in 76.9% of patients who were on mechanical ventilation. Mechanical ventilation is frequented among patients who suffer sICH, putting them at the highest risk for pneumonia of any other patient group (Alsumrain et al., 2013). While the authors maintained these associations, they acknowledged potential confounds including a significant increase in the risk of pneumonia for sICH patients receiving proton pump inhibitor or H2 blockers which suppress gastric acid and lead to a heightened pH and more conducive environment for bacteria. Additionally, the use of angiotensin-converting enzyme inhibitor (ACE-I), specifically among Caucasian patients, was shown to predispose sICH patients to the development of pneumonia, contrary to alternate studies involving Asian populations (Alsumrain et al., 2013).

Estimates of rate of pneumonia vary between studies. Factors involved in the calculated risk of pneumonia include history of chronic respiratory diseases, dysphagia severity, nasogastric tube feeding, level of consciousness and age. These factors should be considered when comparing incidence of pneumonia between studies (Sorensen et al., 2013). Miles et al. (2014) suggested that higher age, cardiac and respiratory comorbidities and male gender were all factors associated with a significantly increased risk of pneumonia. Additionally, dysarthria, denture usage at the time of swallowing assessment along with cerebral atrophy, infarcted foci in the basal ganglia and Barthel Index <100 prior to admission after swallowing assessment were all significantly associated with the onset of aspiration pneumonia (Watanabe et al., 2014). Goda et al. (2015) found significant associations between higher National Institutes of Health Stroke Scale scores, prevalence of facial palsy, endotracheal intubation, and decreased consciousness with the development of pneumonia in patients following stroke.

Factors involved in decreased incidence of aspiration pneumonia were also investigated. Reflux regimens, raising pH of gastric content over 2.5, reduced pre-sleep feeding and elevating the head off the bed were all beneficial in reducing the risk of pneumonia (Johnson et al., 1993). Priority should be given to the identification of prognostic indicators in order to improve the efficacy of prevention efforts. The use of sensitive assessment tools for preventative measures requires increased attention to avoid the detrimental effects that pneumonia has on post-stroke dysphagic patients and caregivers.

Conclusions Regarding the Incidence and Development of Pneumonia Post-Stroke

- **Stroke severity, level of consciousness, age, oral hygiene and other factors contributing to the aspiration of bacterial laden secretions and refluxed material are major indicators for increased risk of pneumonia.**
- **Further research is required to determine the best tools for the prediction, identification and treatment of pneumonia.**

Dysphagia Screening Protocols and Incidence of Pneumonia

Given the heightened risk of developing pneumonia post-stroke, early identification of dysphagia increases treatment options and improves management outcomes. Therefore, the identification of accurate screening protocols may help to control dysphagia and reduce the danger of further complications. A few studies have evaluated whether the implementation of dysphagia screening protocols resulted in a reduction in the incidence of pneumonia (Table 7).

Table 7. Summary of Dysphagia Screening Protocols

Author, Year Study Design (PEDro Score) Sample Size	Intervention	Main Outcome(s) Result
Lakshminarayan et al. (2010) PCT N=18017	E1: Screening protocol C: No screening protocol	• Incidence of pneumonia (-) •
Hinchey et al. (2005) PCT N=2532	E1: Passed screening protocol E2: Failed screening protocol C: No screening protocol	• Incidence of pneumonia: E1 (+)
Yeh et al. (2011) PCT N=176	E1: Screening protocol C: No screening protocol	• Incidence of pneumonia (-) • Incidence of pneumonia (adjusting for age, gender, NIHSS score, nasogastric and endotracheal tube insertion): E1 (+) • Mortality (-)
Sorensen et al. (2013) PCT N=146	E: Gugging Swallowing Screen + oral hygiene care C: Usual care	• Incidence of pneumonia: E (+)

+ Indicates statistically significant differences between treatment groups
- Indicates no statistically significant differences between treatment groups

Discussion

There is some evidence that the initiation of a dysphagia screening program can help to reduce the incidences of pneumonia, presumably through earlier detection and subsequent management of swallowing difficulties. The fact that patients in the Lakshminarayan et al. study who were unscreened had a lower incidence of pneumonia relative to those who were screened but failed suggested that stroke severity was a factor determining which patients were selected for screening (i.e. impaired patients are more likely to be screened) (Lakshminarayan et al., 2010). The authors suggested that clinical judgement on who to screen is not adequate and endorsed the practice of routine dysphagia screening. This is consistent with the findings by Hinchey et al. (2005) who suggested that overall pneumonia rates would be reduced with the implementation of a universal dysphagia screen.

These studies present consistent evidence supporting the use of dysphagia screening protocols for the prevention of pneumonia post-stroke. It is clear that there is a wide variety of viable tools available; however, caution must be taken to avoid using ineffective measures (A. Miles et al., 2013). Patients with dysphagia are at higher risk for pneumonia (Hinchey et al., 2005) but adequate screening tools and dysphagia interventions reduce this risk (Odderson et al., 1995). Based on the results discussed in this section, a standard comprehensive screening assessment should be developed and implemented.

Conclusions Regarding Dysphagia Screening Protocols

- **There is level 2 evidence that the introduction of swallow screening may reduce the incidence of pneumonia among patients with dysphagia when compared to no screening protocol or usual care.**
- **The use of the swallow screen in patients with dysphagia may reduce the incidence of pneumonia compared to when no screening protocols are assigned or compared to usual care.**

Prevention of Pneumonia Post-Stroke

In a massive study, 10,981 post-stroke patients were examined for one-year mortality and cause of death following discharge. Pneumonia accounted for 22.6% of recorded deaths (K. Kimura et al., 2005). A wide range of management strategies for the prevention of aspiration pneumonia have been investigated. These include, but are not limited to: dietary treatments, compensatory strategy/positioning changes, oral hygiene protocols, tube-feeding and pharmacological therapies such as metoclopramide, amantadine, cilostazol or angiotensin-converting enzyme inhibitors (Arai et al., 2003; Arai et al., 1998; Loeb et al., 2003; Ohkubo et al., 2004; Sekizawa et al., 1998; Shinohara, 2006; Yamaya et al., 2001).

A recent meta-analysis was carried out examining the effects of angiotensin-converting enzyme inhibitors (ACE-Is) as a preventative measure for pneumonia among 8,693 post-stroke patients. ACE-Is were found to significantly reduce the risk for pneumonia when compared to placebo or other hypertensive agents. The preventative effects of ACE-Is were more pronounced in Asian versus non-Asian populations. It is well known that cough and swallow reflexes are the primary mechanisms for the protection against aspiration and subsequent pneumonia. It has been established that ACE-Is induce these protective mechanisms (Israili & Hall, 1992; Nakayama et

al., 1998), which may be dysfunctional or inactive in post-stroke patients. Dopamine in the nigrostriatum stimulates the production of substance P (SP) which is associated with the initiation of these swallows and cough reflexes. Cortical malfunction associated with stroke may decrease dopamine metabolism, indirectly inhibiting the production of SP and these protective reflexes (Yamaya et al., 2001). Among the actions of angiotensin-converting enzyme is the degradation and inactivation of SP. ACE-Is prevent this action and result in an accumulation of SP, potentiating the swallowing and cough reflexes (Cascieri et al., 1984; Nakayama et al., 1998; Sekizawa et al., 1996; Shore et al., 1988). However, there are limitations to the use of these drugs. In particular, the development of a treatment resistance cough has been observed and can lead to discontinuation of ACE-I therapy. In the included meta-analysis, a low frequency of cough was associated with imidapril compared to the control enalapril (0.9% vs. 7.0%), suggesting it may be clinical useful. Further studies should investigate a variety of drugs with known effects on cough and swallow reflexes for their potential to reduce risk of pneumonia. Additionally, the molecular mechanism responsible for the observed effects of these drugs needs to be clarified. It is not clear why these drugs are more effective in Asian versus non-Asian individuals, but this association also needs to be examined in greater detail (Shinohara & Origasa, 2012).

Table 8. summarizes several studies that evaluated various interventions for reducing pneumonia post stroke.

Table 8. Summary of Studies Evaluating the Prevention of Pneumonia Post-Stroke

Author, Year **Study Design (PEDro Score)** **Sample Size**	**Intervention**	**Main Outcome(s)** **Result**
Warusevitane et al. (2014) RCT (8) N_{Start}=60 N_{End}=60	E: Metoclopramide C: Placebo	• Incidence of pneumonia: E vs C (+) • Days on antibiotic treatment: E vs C (+) • Episodes of aspiration: E vs C (+) • Mortality (-) • Swallowing outcome: E vs C (+)
Fields (2008) RCT → Pre-Post N_{Start}=345 N_{End}=200	E: Timed Oral Care C: Usual Oral Care	• Ventilator associated pneumonia (+)
Osawa et al. (2013b) Case Series N_{Start}=189 N_{End}=189	E: Cilostazol C: No cilostazol	• Incidence of pneumonia: E vs C (+)

+ Indicates statistically significant differences between treatment groups
- Indicates no statistically significant differences between treatment groups

Discussion

A high quality, moderately powered randomized controlled trial investigated the effects of metoclopramide to prevent pneumonia in stroke patients fed with nasogastric tubes (MAPS). Versus placebo, this drug was found to significantly improve the risk of pneumonia and swallowing function as well as decrease the number of days on antibiotics, incidence of aspiration, level of hypoxia and level of inflammatory markers (Warusevitane et al., 2014). Yavagal et al. (2000) examined the same intervention on an intensive care population. Results from this study indicated that metoclopramide did not improve incidence but instead only delayed the onset of pneumonia. The authors of the MAPS trial refer to the differences between patient populations to provide a potential explanation for the conflicting outcomes. For the prevention of pneumonia, metoclopramide decreases vomiting and consequent aspiration, improves the tone of the lower gastroesophageal sphincter and increases the rate of gastric emptying, reducing risk of regurgitation. The preventative mechanism of this drug is not clear but it may be involved with the antagonism of dopamine and/or improved immunodepression associated with patients suffering from severe stroke (Warusevitane et al., 2014). Larger studies are needed to confirm the results of the MAPS trial.

Ventilator-associated pneumonia (VAP) develops after ≥48 hours of mechanical ventilator support and is known to significantly increase morbidity and mortality amongst intubated patients (Fields, 2008). Bacteria in dental plaque can be transmitted to the lungs via aspiration; this dental plaque can only be successfully removed through tooth brushing. An RCT was conducted to examine the effectiveness of timed oral care as a method to prevent VAP in 345 mechanically ventilated post-stroke patients. The intervention group brushed their teeth every 8 hours, while the control group performed usual oral care. Nurses were given detailed instruction on oral care, including how to properly brush the patients' teeth, tongue and hard palate for the duration of at least 1 minute. The VAP rate for the intervention group dropped to 0% within a week of completing the treatment regime, while VAP developed in four of the control patients (Fields, 2008). Due to the high level of success in the intervention group, the study design changed from an RCT to a pre-post design as the control group was dropped and all intubated patients were started on the oral health care program. The zero rate was maintained until the end of the study period, supporting the conclusion that VAP is preventable with oral-care interventions (Fields, 2008). However, this study had limitations including very little detail reported on group characteristics. Furthermore, the design of the study was inconsistent; the authors dropped the control group after 6 months due to the high success rate of the intervention. Therefore, the lack of concrete evidence to support the use and importance of oral health care interventions in post-stroke populations warrants the need for further investigation.

In a large case series, patients were retrospectively analyzed for the use of cilostazol and its effect on the prevention of aspiration pneumonia. The authors found that this drug significantly decreased the incidence of pneumonia when compared to patients who did not receive the drug (Osawa et al., 2013b). Mechanisms of action may be similar to those observed with metoclopramide, increasing dopamine and SP concentrations (N. Zhang et al., 2009). However, further research is needed comparing cilostazol to placebo for validation of these results.

Conclusions Regarding Prevention of Pneumonia Post-Stroke

- **There is level 1a evidence from a meta-analysis that the use of angiotensin-converting enzyme inhibitors reduces the relative risk of developing pneumonia when compared to placebo or other antihypertensive agents.**
- **There is level 1b evidence that metoclopramide may improve incidence of pneumonia and resultant days on antibiotic treatment, episodes of aspiration, and swallowing outcome in dysphagic patients following stroke compared to placebo. There was no observed effect on mortality.**
- **There is level 4 evidence that cilostazol may improve the incidence of pneumonia when compared to patients not given the drug.**
- **The use of angiotensin-converting enzyme inhibitors, metoclopramide and cilostazol is associated with a drop in the incidence of pneumonia post-stroke; however, further research is required to investigate these associations.**
- **Improving oral care protocols may reduce ventilator associated pneumonia in post-stroke populations.**

Non-Instrumental Methods for Screening and Assessment of Dysphagia

Stroke survivors should be screened for dysphagia as soon as possible after acute stroke has been diagnosed and emergency treatment has been given and before any oral intake is allowed. Ideally, screening should take place as soon as the stroke survivor is awake and alert. Stroke survivors who pass the screening are unlikely to have significant swallowing difficulties and have a minimal risk of dysphagic complications. Individuals who fail the screen are maintained NPO until they can be assessed, preferably before the third day after the stroke by a speech language pathologist. On the other hand, assessment describes the problem in detail, determines the severity of the swallowing problem and identifies optimal management strategies, including the need for a modified diet or enteral feeding. Assessment includes a clinical bedside examination and, if warranted by the clinical signs, an instrumental examination, such as videofluoroscopy (Heart and Stroke Foundation of Ontario, 2002). Some common methods for screening and assessment of dysphagia are described in the following sections.

Clinical Screening Methods

The Agency for Healthcare Research and Quality published “Evidence Report/Technology Assessment on Diagnosis and Treatment of Swallowing Disorders in Acute-Care Stroke Patients” in 1999. One of the conclusions reached by this group was that no screening tool has yet been developed that will accurately detect patients with dysphagia who require more extensive testing. Nevertheless, many screening tools have been developed. Most of these screening tests are comprised of two (or more) components. Typically, there is some form of swallowing trial, which is preceded by a questionnaire or preliminary examination. A description of the most familiar of these tools is presented in the following section.

Water Swallowing Test (WST)

This subset of screening methods is used frequently in clinical practice to diagnose aspiration and prevent pneumonia (Osawa et al., 2013c). There are many variations of the WST all comprised of swallowing a pre-set amount of water as usual or without interruption. During

which, observations of swallowing function are made. Originally, 3oz (90mL) of liquid was used however, difficulty was observed in swallowing large amounts of water in post-stroke and elderly patients so the 3mL modified water swallowing test was developed (Osawa et al., 2013c; Shoji et al., 2010). Currently in the western world, volumes from 10mL to 150mL are used (Osawa et al., 2013c). Different volumes and outcomes are incorporated depending on the study population, researcher and to ensure the safety of all involved.

Gugging Swallowing Screen (GUSS)

The gugging swallowing screen (GUSS) is the only screening tool for dysphagia that utilizes multiple consistencies for testing swallowing function. This is an important factor in acute stroke-related dysphagia, as patients with dysphagia are at an increased likelihood of aspirating liquids compared to semi-solids (John & Berger, 2015). The purpose of the test is to assess severity of aspiration risk and determine recommendations for dietary revisions when necessary. The GUSS is capable of detecting even slight signs of silent aspiration (drooling, delayed swallowing, voice change) (Trapl et al., 2007). The bedside GUSS test begins with a simple swallow test, followed by a direct swallowing test that consists of three subtests: Semisolid Swallowing Trial, Liquid Swallowing Trial, and Solid Swallowing Trial. The semisolid swallowing trial involves swallowing a mixture of pudding consistency generated by mixing 1/3 to 1/2 teaspoon of distilled water and instant food thickener, followed by 5 more 1/2 teaspoons. The liquid swallowing trial involves the swallowing of aqua bi of various amounts: 3ml, 5ml, 10ml, 20 ml, and 50 ml. Finally, in the solid swallowing trial a small piece of dry bread is used as the bolus. This trial is repeated 5 times every 10s (Trapl et al., 2007). The GUSS was found to have 100% sensitivity and 69% specificity at predicting aspiration risk (John & Berger, 2015).

Swallowing Provocation Test (SPT)

The swallowing provocation test (SPT) is a less frequently encountered two-stage screening test that involves the bolus injection of 0.4 mL and then 2.0 mL of distilled water at the suprapharynx through a small nasal catheter (internal diameter 0.5 mm) to elicit an involuntary swallow. The latent time is then recorded from the water injection to the onset of swallowing, which is identified by visual observation of the characteristic laryngeal movement, and measured with a stopwatch. The responses to the SPT are classified as normal or abnormal according to the induction of the swallowing reflex after the water injection. A time of seconds is used as a cut-off point to differentiate a normal from an abnormal swallow (S. Teramoto & Fukuchi, 2000; S Teramoto et al., 1999).

Discussion

There are a variety of techniques and tools available to aid in the detection of dysphagia and aspiration. Once a patient fails a screening test and it has been determined that a problem exists, typically a more comprehensive assessment follows from which, treatment options are determined. To be clinically useful, screening tests need to be valid, reliable, easy to use, non-invasive, quick to administer (15-20 min) and pose little risk to the patient. Although many screening tools have been developed it is unclear how many of them are used in institutions beyond those where they were developed. Many institutions use informal processes, or simply restrict all food and drink until a complete assessment is possible by an SLP. A wide range of sensitivities were reported among the tools we reviewed (0% to 100%). Usually, as sensitivity increased, specificity decreased, such that the number of patients who were incorrectly identified as having dysphagia increased. Generally, screening tools with sensitivity >80%, and a specificity that approaches this figure, are considered to be both valid and clinically useful. The majority of the tools presented above do meet these criteria. Harms et al. (2013) developed

the PANTHERIS score for the prediction of stroke-associated pneumonia using routinely recorded clinical parameters (sensitivity=77.6%, specificity=84%, positive predictive value=67.5%, negative predictive value=89.7%, with a score ≥5). While this tool does not consider dysphagia or stroke severity according to the National Institutes of Health Stroke Scale and was conducted within a single center, it does highlight the opportunity for the development of novel screening techniques and the potential of using multiple clinical variables or screening tools for a more accurate diagnosis of dysphagia and aspiration.

Sorensen et al. (2013) found that the combination of Gugging Swallowing Screen and intensified oral hygiene successfully detected dysphagia and decreased the risk of pneumonia among patients with dysphagia when compared to control groups. However, this study only included patients with moderate to severe dysphagia and normal to reduced levels of consciousness, which may have biased the overall incidence of pneumonia (Sorensen et al., 2013).

The results of a systematic review by Martino et al. (2000) evaluating the screening accuracy of 49 individual clinical screening tests for orophayngeal dysphagia suggested that there was only sufficient evidence to support the value of two tests: abnormal pharyngeal sensation and the 50 mL water-swallowing test. Both of these tests were assessed only for the presence or absence of aspiration. Their associated likelihood ratios were 5.7 (95% CI 2.5-12.9) and 2.5 (95% CI 1.7-3.7), respectively. Limited evidence for screening benefit suggested a reduction in pneumonia, length of hospital stay, personnel costs and patients. More recently, Daniels et al. (2012) reviewed the sensitivity, specificity and positive likelihood ratio of items on 17 screening tools designed to detect aspiration. Items with high sensitivity (>80%) included weak palatal movement, cough on a 50mL and repeated 5mL water swallowing test, dysarthria, weak volitional cough, abnormal voice and reduced pharyngeal sensation. Only one item (impaired pharyngeal response) was associated with a likelihood ratio greater than 10, the clinically relevant threshold.

In addition to multiple component tests, standalone tests can be used to screen for dysphagia. The water-swallowing test (WST) has been studied extensively. It has been used as both a standalone screening method and also as part of a clinical swallowing screening or assessment. The optimal volume of water to use in the WST was assessed in a study by Osawa et al. (2013b). The psychometric properties of the test were assessed using 5mL, 10mL, 30mL, or 60mL volumes in a set of patients with suspected dysphagia after stroke. Clinical usefulness of the WST is best described by high sensitivity and specificity values, all of which were reasonably good across the volumes of water tested. However, when considering the prevention of aspiration, high specificity and positive predictive values are important. In this case, the 60mL WST was indicated as most valuable. An alternative test (the two step thickened water test) has been developed to assess puree food aspiration. The two step thickened water test takes place in two parts. The first part is a pretest evaluation (assessing tongue protrusion, saliva swallowing, vocalization, and voluntary coughing). If successful, the patient completes the second test, which involves swallowing 3g of a paste food (3g of thickening powder dissolved in 200mL of water mixed with pumpkin paste). The absence of coughing and changes in vocalization/respiration suggests a negative test. The two step thickened water test may be a reliable and useful tool for the detection of paste food dysphagia (Momosaki et al., 2013).

From the included studies evaluating the swallowing provocation test (SPT), there were a wide range of sensitivities (SN) and specificities (SP) reported. This variability suggests caution

should be taken before accepting the SPT as a clinically useful tool. The applicability of this test to accurately screen for dysphagia is debatable. However, there is clear evidence of its potential and further research is required to determine parameters that may result in a more consistent outcome. Notable suggestions for its use in clinical practice were made. From Warnecke et al. (2008); nil-by-mouth should be given with abnormal first step SPT or normal first step SPT and clinical signs of impaired oral phase of swallowing. Patients may be tentatively started on oral feeding following normal first step SPT and with no clinical signs of oral phase swallowing dysfunction. Furthermore, since the SPT can be performed without special equipment or active patient cooperation, Teramoto and Fukuchi (2000) suggested that SPT should be administered preferentially over WST in the clinical setting.

A single dysphagia screening with optimal accuracy has yet to be described. In the majority of the studies, small sample sizes and population bias may have affected outcomes. Therefore, further research with larger multicenter trials are required to investigate which of these techniques or combination of techniques are most clinically useful in detecting swallowing impairment.

Conclusions Regarding Non-Instrumental Methods for Screening and Assessment of Dysphagia Post-Stroke

- **A large number of different screening methods exist for dysphagia with a wide variation of sensitivity (0-100%), specificity (50-92%) and predictive values.**
- **There was a wide range of sensitivity (47.8-100%) and specificity (50-100%) values for the water swallowing test and its variations.**
- **There was a wide range of sensitivity (first-step=71.4-100%; second-step=13-76.4%) and specificity (first-step=38-100%; second-step=70.3-100%) values for the swallowing provocation test.**
- **The GUSS screening tool has 100% sensitivity and 69% specificity to predict aspiration risk.**
- **Combination of the Water Swallowing Test and oxygen desaturation test may result in an improvement in the predictive accuracy of detecting aspiration and pneumonia over either of these screening tests conducted alone.**
- **There is no ideal or define volume of water that is used to assess dysphagia on the water swallowing test.**
- **There is a variety of clinical screening tests for determining dysphagia following stroke.**
- **There is a wide range in the validity and clinical usefulness of the water swallowing test and the swallowing provocation test. Further research is required to determine the usefulness of the GUSS test at predicting aspiration risk.**

Bedside Clinical Examinations

Several forms of clinical or bedside swallowing evaluations have been described for the purposes of screening and/or assessment. Some of these methods use clinical markers or indicators, such as irregularities of speech or voice (e.g., dysarthria, dysphonia, vocal change), sensitivity of gag reflex or volitional cough strength, while others evaluate swallowing ability using a combined approach. These methods may or may not include a water-swallowing test to

evaluate voice change after swallow or cough after swallow (Stephanie K Daniels, 2000; S.K. Daniels et al., 1998).

While bedside clinical examinations are associated with reduced clinical validity when compared to instrumental methods, they are frequently used due to their relative ease of administration and acceptable level of usefulness (Warnecke et al., 2008). As mentioned before, early detection of dysphagia may shorten recovery periods and improve patient health outcomes. Bedside clinical examinations are relatively inexpensive and reduce the amount of radiation exposure for patients who may need to have repeat evaluations under videofluoroscopy modified barium swallowing assessments, as well as from over using antibiotics as part of their dysphagia management.

Among the screening tools evaluated, two studies assessed the reliability and validity of the Toronto Bedside Swallowing Screening Test (TOR-BSST) to identify dysphagia. This screening tool combines independent measures with high predictive values in an attempt to produce dysphagia screening results with high sensitivity and negative predictive value between the acute and rehabilitation stages post-stroke (R. Martino et al., 2009). This study found a sensitivity of 91.3% and negative predictive value of 93.3% in acute settings and 89.5% in rehabilitation settings for the TOR-BSST. Recently, Martino et al. (2014) investigated the importance of the specific tools included in the TOR-BSST. The authors found that the number of teaspoons administered in the water swallowing test (WST) portion of this evaluation was the primary contributor to its high validity. Specifically, 10 sequential 5mL teaspoons was the most accurate procedure for detecting dysphagia (specificity=96% versus 79% with five teaspoons or 92% with eight teaspoons). While the WST is the major component contributing to the high predictive value of the TOR-BSST, a lingual motor test is necessary to identify dysphagia in patients who would otherwise have been overlooked by the WST alone (Martino et al., 2014). These two studies provide good support for the TOR-BSST, including at least a water swallowing and lingual motor test, as being more accurate than other single-item screening tools.

Somasundaram et al. (2014) investigated frequently utilized clinical criteria as well as aphasia and buccofacial apraxia (BFA) for the detection of dysphagia in patients with left middle cerebral artery (MCA) stroke. High sensitivities for the predictive value of aphasia and BFA were found (87% and 97%, respectively). The authors suggested that these correlations were due to the neuro-anatomical overlap of cortical control of swallowing function, speech and imitation. The specificity value (31%) was not as encouraging. However, when controlling for aphasia severity, sensitivity dropped to 83% but specificity increased to 54% suggesting a potential correlation between this factor and the risk of dysphagia. Future studies should investigate this relationship (Somasundaram et al., 2014). Additionally, analysis of bedside evaluations failed to reach clinical viability. This may have been due to inclusion of a large proportion of aphasic patients for whom evaluation was not possible due to nonverbal presentation or severely impaired speech production involved with this morbidity. Further research using a larger sample size, multi-center approach and examination of multiple lesion sizes and locations are necessary to determine the true relationship between left MCA stroke and dysphagia.

Conclusions Regarding Bedside Clinical Examinations

- **There was a wide range of sensitivity (68-97%) and specificity (53-86%) values for the different bedside clinical examinations.**
- **There is a wide range in the validity and clinical usefulness of bedside clinical examinations. Further research is required.**

Facial Oral Tract Therapy

Is a multidisciplinary approach rooted in the Bobath concept in the evaluation and treatment of swallowing, eating, oral hygiene, non-verbal communication and speech articulation after a neurological injury. In this therapy, the speech language therapist uses consistent principles to choose between different components to support the patient in performing movements as normal as possible. There is little or no use of verbal instructions because the theoretical assumption is that motor learning occurs through successful performance. Therapy tends to focus on activities of daily living. The speech language pathologist may use techniques of oral stimulation, tongue mobilization, and facilitation of swallowing to create a routine for oral hygiene. The framework of facial oral tract therapy can be summed in a cyclical model of: setting a goal, selecting tasks to achieve that goal, treatment, evaluating patient progress, and identifying and ameliorating problems (Hansen and Jakobsen, 2010).

Alternative Methods

In addition to conventional assessment methods tracheal pH monitoring has also been used experimentally to detect drops in pH, which may indicate aspiration. Clayton et al. (2006) reported that in 9 of 32 patients examined, there was a drop in tracheal pH following ingestion of acidic foods. Tracheal pH was monitored by the use of a sensor, which was inserted into the trachea by the cricothyroid membrane. All patients were studied following the ingestion of foods which had been considered to be safe on the basis of a VMBS examination.

Other forms of clinical assessment have been used to detect the presence of aspiration. Ryu et al. (2004) evaluated voice analysis as a means to clinically predict laryngeal penetration among 93 patients (46% of whom had experienced a stroke) using VFS as the diagnostic gold standard. Of five voice parameters tested (average fundamental frequency, relative average perturbation, shimmer percentage, noise-to-harmonic ratio, and voice turbulence index), relative average perturbation most accurately predicted aspiration.

As reviewed by Ramsey et al. (2003) and Bergstrom et al. (2014), cervical auscultation of the mechanical and/or respiratory components of swallowing, lateral cervical soft tissue radiographs and pharyngeal or esophageal manometry have also been used to detect dysphagia.

While bedside assessment and other non-invasive methods are easy to perform, these methods have been shown to predict poorly the presence of silent aspiration. Smith et al. (2000) reported that aspiration cannot be distinguished from laryngeal penetration using a bedside evaluation, resulting in the over diagnosis of aspiration and, in some cases, unnecessary or excessive

dietary restrictions. Therefore, instrumental methods are frequently used to directly observe the swallowing mechanism and more fully delineate swallowing function.

Conclusions Regarding Alternative Non-Instrumental Dysphagia Screening and Assessment Techniques

- **There are a number of alternative screening and assessment tests available for use in dysphagia assessment/intervention. Further research is required to test their validity in a clinical setting.**

Instrumental Methods Used in the Detection of Dysphagia/Aspiration

Videofluoroscopic Modified Barium Swallow (VMBS) Examination

When aspiration is suspected, the videofluoroscopic modified barium swallow (VMBS) study is often considered the "gold standard" in confirming the diagnosis (Splaingard et al., 1988). A speech-language pathologist in consultation with a radiologist conducts a VMBS study to examine the oral preparatory, oral and pharyngeal phases of swallowing. The patient must have sufficient cognitive and physical skills to undergo testing (Bach et al., 1989). The subject is in a seated position in a chair designed to simulate the typical mealtime posture. Radio-opaque materials of various consistencies are tested: barium impregnated thin and thick liquids, pudding, bread, and cookies are routinely used. Various aspects of oral, laryngeal, and pharyngeal involvement are noted during the radiographic examination (Table 9). The VMBS study may then be followed by a chest x-ray to document any barium that has been aspirated into the tracheobronchial tree.

The VMBS assessment not only establishes the presence and extent of aspiration but may also reveal the mechanism of the swallowing disorder. Aspiration most often results from a functional disturbance in the pharyngeal phase of swallowing related to timing, reduced laryngeal closure or pharyngeal paresis. A VMBS study is recommended in cases where the patient is experiencing obvious problems maintaining adequate hydration/nutrition, where concern is expressed regarding frequent choking while eating, or in the case of recurrent respiratory infections. Other factors such as cognition, recurrent stroke, depression, immunocompromization, and underlying lung disease must also be considered. A definitive criterion to determine if a VMBS study is required has yet to be determined in a systematic and scientific manner. Repeat VMBS studies are usually conducted at the discretion of the SLP/MD based on the progress and prognosis of the individual patient. No standard schedule for re-assessment exists. However, in a recent study, Wilson et al. (2012) demonstrated that VMBS screening for dysphagia was cost-effective compared to bedside examinations or a combination of bedside examinations plus VMBS studies for patients thought to be at high risk. The savings were realized by a reduction in the number of patients who developed pneumonia associated with VMBS screening, who did not require treatment for pneumonia (estimated cost /person=$25,000).

Table 9. Radiological Evaluation During VMBS (Bach et al., 1989)

Oral Phase

- Lips: Closure
- Tongue: Anterior and posterior motion with consonants; motion and coordination during transport, and manipulation of bolus
- Soft palate: Evaluation and retraction with consonants
- Jaw: Motion
- Oral: Pocketing

Pharyngeal Phase

- Swallow: Delay, absence
- Peristalsis: Residue in valleculae, pyriform sinuses nasopharyngeal regurgitation

Laryngeal Function

- Elevation of larynx
- Penetration into laryngeal vestibule
- Aspiration
- Cough: Presence, delay, effectiveness
- Vocal cord function

Post-Exam Chest X-Ray

- Chronic changes
- Presence of barium in valleculae, pyriform sinuses, tracheobroncheal tree, lungs

While VMBS studies can be useful in analyzing the anatomic structures, physiology of the swallow as well as detecting silent aspiration, there are some disadvantages: i) The procedure is relatively complex, time consuming and resource intensive; ii) there is some exposure to small amounts of radiation; iii) the test is not appropriate for some patients who may have difficulty sitting in an upright position in a chair. The results of the test can also be difficult to interpret and there can be significant variation among individual raters (Ramsey et al., 2003). Therefore, in certain cases this tool may not be suitable for screening or frequent test repetition (Humphreys et al., 1987; Muz et al., 1991).

One solution to these limitations may be the combined use of scintigraphy along with VMBS studies. Using small amounts of radioactive material, scintigraphy can provide two-dimensional images to diagnose and assess the severity of a variety of bodily conditions (K. H. Silver & Van Nostrand, 1992). While pharyngeal scintigraphy cannot show the exact anatomic site of swallowing dysfunction, there are alternate advantages that may make it a clinically useful adjunct to videofluoroscopy. These include: exposure to low amounts of radiation and efficient measurement of the timing of events and volume of the bolus (Hamlet et al., 1989; Jeri A Logemann et al., 2005; Shaw et al., 2004). The value of this technique is attributed to its ability to describe specific parameters of swallowing function associated with dysphagia and subsequent aspiration. One study investigated the correlation between scintigraphy and videofluoroscopy as well as the ability of scintigraphy to predict penetration and/or aspiration according to three parameters associated with risk of aspiration [premature pharyngeal entry (PPE), pharyngeal transit time (PTT), post-swallow pharyngeal stasis (PPS)]. Scintigraphy readings from all three measures were significantly correlated with videofluoroscopic results. Additionally, the predictive values of this technique for detecting penetration and/or aspiration

were good, suggesting that it may be beneficial when used in conjunction with VMBS studies (Y. H. Huang et al., 2013).

Conclusions Regarding VMBS Examination

- **Videofluoroscopic Modified Barium Swallow studies are considered the gold standard for dysphagia/aspiration diagnosis.**
- **There is level 3 evidence that scintigraphic and videofluoroscopic (VFS) results may be associated with swallowing function. Furthermore, scintigraphy provided good predictive values for VFS results (70-95%).**
- **Sensitivity and specificity values for scintigraphy in predicting laryngeal penetration and/or aspiration were between 17-77% and 69-92%, respectively.**
- **Videofluoroscopic Modified Barium Swallow (VMBS) studies are considered the gold standard for dysphagia/aspiration diagnosis. Further research is required to determine conclusively when a VMBS study should be administered or re-adminstered.**
- **Scintigraphy may be a valid tool for the detection of aspiration and penetration in dysphagia. Further research is required.**

Flexible Endoscopic Evaluation of Swallowing (FEES)

Although VMBS studies are considered the gold standard for detection of aspiration, other clinical assessment techniques, designed to be less invasive, cheaper and easier to administer are in current use. Flexible endoscopic examination of swallowing (FEES), also referred to as fibertopic endoscopic evaluation of swallowing, is also recognized as an objective tool for the assessment of swallowing function and aspiration. The method has been demonstrated to be safe and well-tolerated (Warnecke et al., 2009). FEES is a procedure that allows for the direct viewing of swallowing function. The procedure involves passing a very thin flexible fiberoptic tube through the nose to obtain a view directly into the pharynx during swallowing. FEES allows for the full evaluation of the swallow function as food passes from the mouth into the throat. It is able to identify functional abnormalities that may occur and is used in 'practice swallows' to help determine the safest position and food texture to maximize nutritional status and eliminate the risk of aspiration and unsafe swallowing. In addition to assessing the motor components of swallowing, FEES can also include a sensory testing assessment when an air pulse is delivered to the mucosa innervated by the superior laryngeal nerve. This form of assessment is known as flexible endoscopic examination of swallowing with sensory testing (FEESST). This technique was shown to be safe when used to assess the swallowing function of 500 consecutive subjects. There were only three occurrences of nosebleeds and no instances of a compromised airway. The procedure was generally found to be, at worst, mildly uncomfortable (Aviv et al., 2000).

Table 10. Summary of Flexible Endoscopic Evaluation of Swallowing

Author, Year Study Design (PEDro Score) Sample Size	Intervention	Main Outcome(s) Result
Kjaersgaard et al. (2014) RCT (7) N_{Start}=138 N_{End}=119	E: Flexible endoscopic evaluation of swallowing C: Facial oral tract therapy	• Total number of infections (-) • Incidence of pneumonia: C (-)
Aviv (2000) Cohort N=139	E1: Flexible endoscopic evaluation of swallowing with sensory testing E2: Videofluoroscopic modified barium swallow study	• Incidence of pneumonia in patients with stroke: E1 (+)
Bax et al. (2014) Case Series N_{Start}=440 N_{End}=440	E: Fiberoptic endoscopic evaluation of swallowing C: No fiberoptic endoscopic evaluation of swallowing	• Incidence of pneumonia: E (+) • Instrumental assessment: E (+) • Standard diet at discharge: E (+) • Period of non-oral feeding: E (+) • Number of patients orally fed (-) • Length of stay: I (+) • Mortality (-)

+ Indicates statistically significant differences between treatment groups
- Indicates no statistically significant differences between treatment groups

Discussion

As a result of the multiple benefits of flexible endoscopic evaluation of swallowing (FEES) (reliability, safety, ease of administration, low cost and lack of exposure to radiation), this tool has gained much support for the detection of dysphagia, particularly in acute stroke (Bax et al., 2014). One study suggested that a SLP-led FEES service significantly decreased the risk of pneumonia and improved discharge diet versus no FEES however, these benefits came at the cost of increased length of stay in hospital and additional time on non-oral feeding. The authors suggested that all of these results are valuable in the treatment of post-stroke dysphagia. FEES in combination with a cough reflex test and clinical bedside swallowing evaluation may focus the criteria for FEES candidacy to make this service more efficient and productive. The selection of patients for referral to instrumental assessment may be improved by the use of these assessments in conjunction since they provide stronger evidence for the presence of dysphagia and subsequent complications among those who fail the cough reflex test (Bax et al., 2014). Furthermore, conflicting evidence from other studies suggests that an increase in the length of hospital stay is associated with increased rates of pneumonia (Finlayson et al., 2011; Wilson & Howe, 2012). However, significant results suggesting the opposite are true in the study by Bax et al. (2014). The authors explain that this relationship may be due to the provision of FEES leading to a higher referral rate to swallowing rehabilitation, as a result, and a subsequent increase in length of stay to accommodate dysphagia treatment. In support of this conclusion, there was an increase in the proportion of patients leaving the hospital on normal diets. Overall,

the use of FEES, especially in combination with cough reflex testing, seems to ultimately benefit patient health outcomes.

A good quality RCT assessed the use of Facial-Oral Tract Therapy (FOTT) versus FEES as a standard assessment indicating the opportunity for initiation of oral feeding (Kjaersgaard et al., 2014). After excluding patients who developed pneumonia outside of the primary study criteria, there was no difference in the incidence of this respiratory infection between the two groups (3/62 FOTT patients; 4 of 57 FEES patients). These results were supported in a study by Barquist et al. (2001) who found that the risk of pneumonia was not different between 70 patients exposed to either FEES or clinical assessment within 48 hours of endotracheal intubation. Surprisingly, it seems that FEES may be equally beneficial to some clinical non-instrumental assessments such as FOTT in reducing the risk of aspiration pneumonia after starting oral feeding.

Aviv et al. (2000) compared the incidence of pneumonia over a one-year period between patients managed by VMBS or FEES. Among the stroke patients, the incidence of pneumonia managed by FEESST was significantly lower. The authors speculated that one of the reasons for the lower incidence might be due to the sensory testing component of the FEES examination, which was absent from VMBS evaluation, was used to more effectively guide management.

Rather than attempt to compare the accuracy of swallowing abnormalities assessed between VMBS and FEES evaluations, Leder and Espinosa (2002) compared the ability of six clinical identifiers of aspiration (dysphonia, dysarthria, abnormal gag reflex, weak volitional cough, cough after swallow, and voice change after swallow) with FEES to determine the accuracy of predicting aspiration risk following stroke (Leder & Espinosa, 2002). Their results suggest that the ability of the test to correctly identify patients not at risk of aspiration was poor using clinical criteria.

Conclusions Regarding Flexible Endoscopic Evaluation of Swallowing

- **There is conflicting level 1b and level 2 evidence regarding the reported incidence of pneumonia after flexible endoscopic evaluation of swallowing (FEES) is used versus facial oral tract therapy or videofluoroscopy.**
- **There is level 4 evidence from a large case series study indicating that the incidence of pneumonia may be reduced when dysphagic patients are assessed with FEES versus no assessment. Additionally, FEES may be responsible for a higher proportion of patients treated with instrumental assessment and on standard diet at discharge which may be related to longer periods of non-oral feeding.**
- **Flexible endoscopic evaluation of swallowing may reduce the incidence of pneumonia and improve other important factors associated with dysphagia recovery; however, the evidence is limited and further research is required.**

Pulse Oximetry

Pulse oximetry has been suggested as a method in detecting aspiration, based on the principle that aspiration of food into the airway leads to bronchospasm or airway obstruction, which leads to a reduction in oxygen saturation. This technique is non-invasive, requires little patient cooperation and is easy to obtain (Sellars et al., 1998). However, the accuracy of pulse oximetry in detecting aspiration is unproven and it remains uncertain whether oxygen desaturation can predict aspiration.

There is conflicting evidence on the efficacy of pulse oximetry. Wang et al. (2005) reported no significant association between a reduction in oxygen saturation and aspiration, identified simultaneously by VFS, among 60 patients with dysphagia due to stroke and nasopharygeal cancer. This was seen also in a older study by Sellars et al. (1998) concluding that caution should be taken when considering the use of this tool as a clinically viable option for detecting aspiration. Although, results from this study may not be representative of the population due to the extremely limited sample size used. Alternatively, Collins & Bakheit (1997) reported that pulse oximetry could be used to detect a high proportion of stroke patients who aspirated on VMBS (81.5%). Three additional studies support the legitimacy of this method and have suggested that its diagnostic accuracy improves further when used in conjunction with a bedside swallowing evaluation (Ramsey et al., 2003; Smith et al., 2000).

Age may also be a factor in predicting oxygen saturation. Rowat et al. (2000) reported that the baseline oxygen saturation among a group of stroke patients deemed safe to feed orally was significantly lower compared to both hospitalized elderly patients and young healthy subjects (95.7 vs. 96.7 vs. 97.9%, $p<0.001$). However, Tomii (2011) and Sherman et al. (1998) stated that age, gender or diagnosis were not associated with oxygen saturation.

Although pulse oximetry is a quick and non-invasive method to detect aspiration following stroke, its association with oxygen desaturation have been inconclusive. Generally, its performance when measured against VMBS studies has been poor as the low sensitivities/specificities from the above studies will attest to. Furthermore, the evidence offered is plagued by low sample sizes, variable age among participants and the agedness of the included studies, all of which indicate a need for further research to update the current understanding of pulse oximetry as an instrumental method for the detection of dysphagia and aspiration.

Conclusions Regarding Pulse Oximetry

- **It is unclear whether pulse oximetry is a useful tool in the detection of dysphagia and aspiration following stroke. The low sensitivity and specificity values reported (minimum 13% and 39%, respectively) call into question its clinical validity.**
- **It is unclear whether pulse oximetry is a clinically viable tool for the detection of dysphagia and aspiration following stroke. Further research is required.**

Ultrasonography

Ultrasonography has been suggested as a potential new method for the assessment of dysphagia after stroke. It is thought to offer a more practical bedside approach to evaluating swallowing function compared to the traditional VFSS and FEES (Tomii et al., 2011). Alternatively, this method can present additional information to supplement other bedside assessments or these instrumental techniques. However, previous studies have not discussed quantitative measures provided by ultrasonography for the diagnosis of swallowing dysfunction in order to objectively measure the severity of dysphagia (Hsiao et al., 2012).

Ultrasonography is able to capture mechanisms in action during both the oral and pharyngeal phases of swallowing. In the first study included above, larynx elevation and tongue thickness were assessed by submental ultrasonography. Tongue mobility is involved in the prevention of oral leakage as well as preparation and propulsion of the bolus into the pharynx. Tongue thickness is a direct measure of tongue mobility and therefore, a reduction of thickness may indicate impaired swallowing function. Additionally, airway protection as a result of larynx elevation is controlled by hyoid bone displacement. Consequently, reduced hyoid bone displacement is a potential precursor to the development of aspiration. Together these two factors are major contributors to an intact swallowing mechanism (Hsiao et al., 2012). Hsiao et al. (2012) found that a hyoid bone displacement less than 1.5 cm and a change of tongue thickness less than 1.0 cm were significantly associated with swallowing dysfunction.

Park et al. (2015) used M-mode sonography to investigate the effects of dysphagia and aspiration on respiratory function associated with diaphragm excursion. The diaphragm is responsible for the majority of airflow into the lungs and is an important structure for proper respiratory function however, post-stroke patients may have altered diaphragm excursion (E. Cohen et al., 1994; Voyvoda et al., 2012). This can lead to impaired cough and a subsequent increase in the risk of aspiration and pneumonia. Diaphragm excursion was observed to be weakest among stroke patients with dysphagia when compared to those without dysphagia and healthy controls. On the patient's side affected by hemiplegia, the authors observed reduced excursion which consequently increased incidence of pneumonia when compared to the unaffected side (G. Y. Park et al., 2015).

Both studies discussed the complications of dysphagia and aspiration in relation to measurements of specific mechanisms involved in swallowing function made by ultrasonography. However, specific reference of this instrumental assessment as a dysphagia screening tool was discussed as a secondary outcome. It was mentioned that ultrasonography may be comparable to videofluoroscopy (Hsiao et al., 2012) but the limited information presented highlights the need for further large-scale studies investigating this tool as it is related to the detection of dysphagia and aspiration. It may serve as a useful adjunct to VMBS and FEES.

Conclusions Regarding Ultrasonography

- **There is level 2 evidence that both ultrasonography and videofluoroscopy provide comparable results.**

- **There is level 2 evidence that ultrasonography may be able to identify significant differences between factors involved in the diagnosis of dysphagia while approaching high levels of sensitivity (70-73.3%) and specificity (66.7-66.7%).**

Management of Dysphasia

The careful management of dysphagia is essential for successful rehabilitation in acute brain injury patients (Hoppers & Holm, 1999). For patients with dysphagia following head injury, based on the status of swallowing function at the time of admission, three distinct types of rehabilitation programs have been described: 1) non-feeding, 2) facilitation and feeding, and 3) progressive feeding (Winstein, 1983). One goal of dysphagia treatment is to have individuals become independent in their feeding skills. It's known that individuals with dysphagia that are fed by someone else have a 20 times greater risk of pneumonia than those who are able to feed themselves (Langmore et al., 1998).

The non-feeding program was designed as a stimulation program for very low-level patients, in order to prepare them for later feeding. It includes desensitization techniques (e.g., stroking, applying pressure, or stretching) to facilitate normal swallowing, sucking, and intraoral responses (Winstein, 1983). The facilitation and feeding program use small amounts of puree consistency food to promote normal feeding patterns (Winstein, 1983). Finally, the progressive feeding program uses specialized techniques to help the patient develop swallowing endurance by systematically increasing the amount of oral intake. This progressive feeding program continues until the patient can consume a complete meal within thirty minutes without difficulty (Winstein, 1983).

For patients who are safe with some form of oral intake, therapeutic strategies utilized in dysphagia management can be divided into two categories: (a) compensatory treatment techniques and (b) therapy techniques (Logemann, 1999). Compensatory treatment techniques do not involve direct treatment of the swallowing disorder, rather they reduce or eliminate the symptoms of dysphagia and risk of aspiration by altering how swallowing occurs (Logemann, 1991, 1999). The types of compensatory strategies include: (a) postural adjustment of the head, neck, and body to modify the dimensions of the pharynx and improve the flow of the bolus, (b) sensory stimulation techniques used to improve sensory input either prior to or during the swallow, (c) food consistency and viscosity alterations, (d) modifying the volume and rate of food/fluid presentation, and (e) use of intraoral prosthetics (Logemann, 1999). Conversely, therapy techniques are designed to alter the swallow physiology (Logemann, 1999). They include range-of-motion and bolus handling tasks to improve neuromuscular control without actually swallowing. They also include swallowing maneuvers that target specific aspects of the pharyngeal stage of the swallow. Medical and surgical management techniques are included in this category (Logemann, 1999), with these interventions typically only introduced once trials with more traditional behavioural treatment techniques have proven to be unsuccessful.

Several interventions have been investigated for the treatment of dysphagia. Included among these are vocal fold adduction exercises, range of motion exercises for the lips, tongue, and jaw, and chewing exercises (Logemann, 1993).

Oral Motor Exercises

Exercises introduced with those who have developed a swallowing disorder include various oral motor exercises, such as range of motion exercises for the tongue and the pharyngeal

structures (Logemann, 1998). These exercises are designed to improve strength, movement, awareness, and muscle coordination when swallowing (Kramer et al., 2007). To aid in the improvement of oral transit, exercises to assist in tongue elevation and lateralization may be implemented. Here the patient may be asked to perform very specific tongue exercises in an effort to improve speech and swallowing (Logemann, 1998). Individuals may also be asked to participate in tongue resistance exercises (pushing the tongue against a tongue blade or popsicle stick for 1 second) and bolus control exercises (to allow the patient to learn to control or manipulate items placed in the mouth) (Logemann, 1998).

Range of Motion Exercises

When participating in range of motion exercises, the individual is asked to bear down while holding his or her breath from a seated position. This exercise is not recommended for those with uncontrolled blood pressure (Logemann, 1998). It is recommended that this exercise be done 5 to 10 times each day for 5 minutes.

Vocal Fold Adduction Exercises

Vocal fold adduction exercises aim to improve vocal quality and reduce the risk of aspiration. Individuals are asked to bear down, with one hand against a chair while producing a clear voice. This is done five times. The individual is then asked to repeat an “ah” sound five times. Again, it is recommended that these exercises be repeated three times in sequence, 5 to 10 times each day for five minutes. If there is no significant improvement in swallowing at the end of one week, individuals may be asked to pull up on the seat of a chair, while sitting in it, and prolong phonation (Logemann, 1998). This exercise is recommended for those individuals whose vocal folds fail to close completely (Kramer et al., 2007).

Strengthening Exercises

Exercises which strengthen the muscles in the throat and neck may improve swallowing function. However, patients need to be able to physically complete the required motions without injury in order to use this treatment method (Kraaijenga et al., 2015).

The Shaker Exercise

For the Shaker exercise, patients are asked to lay flat on the floor or in bed and raise their heads high enough to see their toes. This position is held for one minute, and then the patient rests for one minute. The exercise is repeated three times. Following this sequence, the patient lifts their head, looks at their toes, and then lowers their head. This head up then down sequence is repeated 30 times. It is recommended that the Shaker exercise be completed three times per day for a period of six weeks. This exercise has been shown to have some success in improving hyolaryngeal movement (Logemann, 1998; Shaker et al., 2002; Shaker et al., 1997), however, it has not been studied specifically in the ABI population.

Chin Tuck Against Resistance

An alternative exercise to strengthen suprahyoid muscles is the chin tuck against resistance exercise. This involves two steps for participants: 1) squeezing a rubber ball by tucking the chin in for 10s (isometric) and 2) squeezing a rubber ball with the chin as hard as possible 10 consecutive times (isokinetic) (Yoon et al., 2014). A preliminary study using healthy subjects evaluating the potential use of the chin tuck against resistance exercise in populations with dysphagia concluded that this method resulted in greater maximum surface electromyography when compared to the Shaker exercise (Yoon et al., 2014). However, in order to determine the

effectiveness of exercising suprahyoid muscles for dysphagia the authors stated that clinical trials are needed (Sze et al., 2016; Yoon et al., 2014).

Swallow Maneuvers

During the acute stage of recovery, patients may experience more swallowing difficulties than they do during later rehabilitation. Failing to address and treat swallowing difficulties in the early stages may lead to compliance issues with the recommended diets, and possible setbacks secondary to aspiration pneumonia. Overall, this can hinder the patient's ability to participate in formal rehabilitation. Post-ABI swallowing difficulties are often the result of eating too quickly, taking large bites, cognitive impairments, and decreased swallowing sensitivity (Logemann, 1998). Swallowing difficulties can be addressed through four maneuvers but they require the patient to follow directions, be alert, and be able to exert the physical effort it takes to perform the maneuvers correctly (Kramer et al., 2007).

Supraglottic Swallow

This maneuver is meant to close the airway at the level of the true vocal folds before and during the swallow, as well as clear residue afterwards (Logemann, 1998; Logemann et al., 1997). Individuals are asked to hold their breath while swallowing and then to cough immediately after the swallow. This maneuver encourages closure of the true vocal cords in an effort to address reduced or delayed vocal fold closure or delayed pharyngeal swallow. The cough portion of this maneuver is meant to eject any objects or residue within the laryngeal vestibule.

Super-Supraglottic Swallow

This maneuver targets closure of the entrance to the airway both before and during the swallow, increases pressure generation, and aims to clear residue after the swallow is complete (Logemann, 1998). During this maneuver the patient completes the following sequence: 1) take a deep breath, 2) hold the breath while bearing down hard, 3) swallow hard while holding this breath, 4) cough immediately after the swallow and clear throat, and 5) swallow again (Logemann et al., 1997).

Effortful Swallow

Effortful swallow is meant to increase posterior movement of the tongue base (Kramer et al., 2007). This technique involves asking the individual, as they swallow, to squeeze hard with all the muscles they use for swallowing (throat and neck muscles).

Mendelsohn Maneuver

The objective of this maneuver is to address decreased laryngeal movement and discoordination of the swallow. Improvements in swallowing function are achieved through increasing the extent and duration of laryngeal elevation which increases the duration and width of the cricopharyngeal opening (Logemann, 1998). Typically, patients are asked to swallow, but as they do so, to hold their larynx (i.e. Adam's apple) elevated for two to three seconds prior to completing the swallow.

Thermal-tactile Stimulation

Thermal stimulation or thermal-tactile stimulation was developed to stimulate the swallowing reflex in patients who have neurological impairment (Lazzara et al., 1986). The procedure for

thermal-tactile stimulation involves having the patient open their mouth and applying a cold laryngeal mirror to the base of the faucial arches. The mirror, while being in contact with the arch, is rubbed up and down five times. For those patients who have sustained a trauma, contact will be made on the normal (non-injured) side of the mouth (Logemann, 1998). Pharyngeal swallow may not be triggered at the time of stimulation, but the purpose is to heighten the sensitivity for swallowing via the central nervous system. It is hoped that once a patient attempts to swallow, the pharyngeal swallow will be triggered more quickly (Logemann, 1998).

The use of a chilled laryngeal mirror applied to the anterior faucial pillars (three strokes per side) before swallowing was compared to 10 consecutive swallows of semi-solid boluses in 22 patients with dysphagia post stroke (Rosenbek et al., 1996). Following the stimulation, patients were asked to swallow a bolus. Results indicated that the duration of stage transition and total swallow duration was reduced following thermal stimulation (Rosenbek et al., 1996). This method requires further research before conclusions on its efficacy in post-ABI populations may be made.

Postural Techniques

Physically moving the patient in order to change the position of the head, neck, and/or body may assist in changing the direction of the bolus flow, thereby improving pharyngeal clearance and/or reducing the risk of aspiration. Five postures that have been shown to have some success in assisting individuals improve their swallowing function are presented in Table 11 below (Logemann, 2008).

For individuals with significant cognitive deficits post injury, having the patient engage in any one of these techniques may be challenging. It has been suggested that patients with oral and pharyngeal deficits consistently do the following: remain upright for 30 minutes post meal to reduce the risk of aspiration, take controlled bites/sips, alternate solids and liquids, take multiple swallows, and clear or remove food that has pocketed in the mouth (Kramer et al., 2007).

Table 11. Five Postures to Improve Swallowing Function (Logemann, 2008)

1. Chin Down Posture	• Helpful for those who have tongue base retraction issues; • Mechanism of change widens the valleculae, allowing the valleculae to contain the bolus in event of pharyngeal delay.
2. Chin Up Posture	• Helpful for those who have oral tongue propulsion problems; • Aids in gaining adequate lingual pressure to drive the food or liquid out of the mouth and into the pharynx.
3. Head Turn (left or right)	• Involves rotating the head to the side that is damaged; • Bolus is then directed through the “normal” safe side.
4. Head Tilt (left or right)	• Head is tilted toward the stronger side, to promote the flow of food and liquid through that side.

5. Lying Down	• Effective in those with posterior pharyngeal wall contraction or reduced laryngeal elevation with resulting residue and subsequent aspiration after swallowing. • Residual or pooling of food or liquid in the pharynx is less able to enter the airway as gravity pulls the bolus towards the posterior pharyngeal wall and in more easily moved through to the esophagus (Drake et al., 1997; Rasley et al., 1993).

Passy-Muir Speaking Valve (PMV)

Passy-Muir (Positive Closure) Speaking Valves (PMV) can improve voice quality and speech production while, at the same time, improving swallowing and reducing aspiration risks (Passy-Muir Incorporated, 2004). Aspiration is often problematic in patients who have a tracheostomy. These patients are essentially unable to achieve the apneic interval necessary for an efficient swallow. It is thought that, normalization of subglottic air pressure, achieved through placement of a PMV, reduces the potential for aspiration.

The valve may be attached to the 15mm connector found on most adult tracheostomy tubes (Dettelbach et al., 1995; Passy et al., 1993). With the PMV in place, a noticeable decrease in the amount aspirated has been observed. While wearing the valve, patients also have the opportunity to more easily express themselves verbally (Bell, 1996). Passy et al. (1993) found that patients began speaking almost immediately and their speech improved making it easier for them to communicate with hospital staff, doctors, and family. This ease of communication is very beneficial to the patient's ability to direct their own care related to feeding, swallowing and diet preferences.

Within the literature, the benefits of the PMV have been supported. Manzano et al. (1993) found that patients experienced a decrease in secretions and showed improvement in ability to cough with the PMV in place. Further supporting its effectiveness, the volume of secretions appears to increase when the PMV is removed (Lichtman et al., 1995; Passy et al., 1993). The use of a PMV has also been shown to significantly reduce aspiration (Elpern et al., 2000; Stachler et al., 1996), provide the ability to safely ingest thin liquids (Suiter et al., 2003), improve oxygenation, decrease oral and nasal secretions, improve sense of smell, enhance airway clearance, and improve swallowing (Bell, 1996). To determine its effectiveness specifically within the ABI population more research is recommended.

International Dysphagia Diet Standardization Initiative

In 2013 an International Dysphagia Diet Standardization Initiative committee was formed from a volunteer group of individuals in nutrition & dietetics, medicine, speech-language pathologists, occupational therapy, nursing, patient safety, engineering, food science & technology. The goal was to develop standardization in terminology used in describing dysphagia diets for individuals across age, care settings and cultures, internationally. The work by this committee resulted in the creation of what is now known as the International Dysphagia Diet Framework (Initiative, 2018).

Research efforts by Steele et al. 2018 to evaluate the International Dysphagia Diet Standardization Initiative Functional Diet Scale showed strong consensual validity, criterion

validity, and interrater reliability (Steele et al., 2018). In their study, 176 respondents from 29 countries completed a web-based survey related to 16 clinical cases. They found poorest consensus with the cases "involving liquid-only diets, transition from non-oral feeding, or trial diet advances in therapy". Perhaps more telling was the finding that "most (>70%) respondents indicated enthusiasm for implementing the International Dysphagia Diet Standardization Initiative Functional Diet Scale" in general (Steele et al., 2018). This certainly speaks to great need for standardization of language and descriptors in providing best practices in therapeutic diet interventions.

Table 12. A Description of Four Levels of Diets

Level 1	Soft textured foods – may be pureed or mashed foods. Pudding may also be given.
Level 2	Minced and Moist – foods are soft, minced. This may include cooked cereals, yogurts, curds.
Level 3	Smooth pureed – foods may include soft bananas, ground meats and fish, cream soups, ice-cream etc.
Level 4	Foods are finely chopped.

Table 13. Diet Levels as Defined by a Canadian Hospital (Parkwood Institute-SJHC)

Dysphagia Diet Fluids	
Thin Fluids	All fluids that are thin at room temperature: water/ice chips/juices/ tea/liquid nutritional supplements/ regular or strained soups/ice cream/jello.
Nectar Thick Fluids	Thin fluids that are thickened to the consistency of nectar and are sipped from a cup: nectar thick juices, milk, water, soup.
Honey Thick Fluids	Thin fluids that are thickened to the consistency of liquid honey but can be sipped from a cup: honey thick juices, milk, water, soup.
Honey Thick/Thin Fluids	Honey thickened fluids with the addition of thin fluids as determined in consultation with the patients/ resident/SDM and the SLP/RD.
Honey Thick Clear Fluids	Only honey thickened CLEAR fluids are allowed (no textures): honey thick apple/orange/cranberry juice and honey thick water.
Honey Thick Full Fluids	Only honey thickened FULL fluids are allowed (no textures): honey thick juices/water/mild/soup/hot cereals/custard/pudding/smooth yogurt.
Pudding Thick Fluids	Thin Fluids that are thickened to the consistency of pudding and are eaten with a spoon: pudding thick juices/mild/water/soup/custards, high energy puddings/smooth yogurt.
Pudding Thick/Thin Fluids	Pudding thickened fluids with the addition of thin fluids as determined in consultation with the patient/resident/SDM/and the SLP/RD.

Pudding Thick Clear Fluids	Only pudding thickened CLEAR fluids are allowed (no textures): pudding thick/apple/cranberry juices and pudding thick water.
Pudding Thick Full Fluids	Only pudding thickened FULL fluids are allowed (no textures): pudding thick juices/water/mild/soups: hot cereals, custard, pudding, smooth yogurt.
Dysphagia Diet Textures	
Regular	All items are served unmodified.
Ready	Same as regular but roast meats are diced.
Diced Meat/Modified Vegetable	Most meats are diced/soft proteins are allowed whole (meatloaf); also allowed: bananas, watermelon, strawberries etc); not allowed: raw vegetables, brussel sprouts, large pieces of cauliflower, whole corn.
Minced meat/Modified Vegetable	Most meats are minced, soft protein items are allowed, nothing on a bun, no brussel sprouts, florets of cauliflower or broccoli, no stir fry (mince before serving); allowed: mashed potatoes, macaroni salads, bananas, sliced strawberries and seedless watermelon.
Minced	Minced meats, vegetables, mashed potatoes, potato puffs, scalloped potatoes, cheese, peanut butter sandwiches, fresh bananas, minced strawberries, seedless watermelon.
Minced/Pureed	Minced mead and vegetables, mashed potatoes (not rice), soft casseroles, scrambled eggs, pureed fruits, strained soups, oatmeal or cream of wheat.
Pureed Entrée/Modified Bread	Same as above; can add crustless bread toast, moist cakes.
Pureed with oatmeal	Oatmeal, foods with a pudding type consistency, all entree must be pureed.
Pureed	All foods with a pudding type consistency, all entrees to be pureed, bread with diet syrup. No bananas, cottage cheese, oatmeal, old cereal, peanut butter.

Dysphagia Diet Guidelines, Parkwood Institute, St. Joseph's Health Care London, London, Ontario

Interventions for dysphagia rehabilitation

Dietary Modification

Adapted from: https://dysphagiacafe.com/2019/02/16/transitioning-into-the-iddsi/

Dysphagia diets have three purposes: 1) to decrease the risk of aspiration, 2) to provide adequate nutrients and fluids, and 3) to provide a progressive approach to feeding based on improvement or deterioration of swallowing function (Bach et al., 1989). No single dysphagia diet exists however, and the standards for texture-modifications vary among countries. Avoidance or careful regulation of thin liquids is a common dietary modification, as this food consistency is the most likely to be aspirated. Thin fluids are poorly manipulated in transit through the oral-pharynx. Eventually patients are allowed thin liquids when it has been established that the patient can successfully swallow without aspirating. Special techniques such as compensatory head and neck postures (Jeri A. Logemann & Logemann, 1983), double swallowing or coughing after swallowing (Horner et al., 1988) may be employed.

Four RCTs were found evaluating dietary modifications for dysphagia rehabilitation. Three RCTs compared a thin/liquid fluid diet to a thickened fluid diet (Diniz et al., 2009; Garon et al., 1997; Groher et al., 1987). One RCT compared thick fluids prepared with a viscometer to thick fluids prepared manually (Goulding & Bakheit, 2000).

The methodological details and results of all four RCTs are presented in in **Table 14.**

Table 14. RCTs examining dietary modifications for dysphagia

Authors (Year) Study Design (PEDro Score) Sample Size$_{start}$ Sample Size$_{end}$ Time post stroke category	Interventions Duration: Session length, frequency per week for total number of weeks	Outcome Measures Result (direction of effect)
Thin/liquid fluid diet vs Thick fluid diet		
Diniz et al. (2009) Cross-over RCT (6) N_{start}=61 N_{end}=61 TPS=Subacute	E1: Liquid samples E2: Spoon-thick liquid samples Duration: 2 trial meals	• Incidence of Aspiration (+exp$_2$) • Incidence of Penetration (+exp$_2$)
Garon et al. (1997) RCT (5) N_{start}=20 N_{end}=20 TPS=Acute	E: Dysphagia diet (unlimited water between meals) C: Regular dysphagia diet (thickened fluids) Duration: fed 3x/d for up to 4wks	• Total Fluid Intake (-) • Incidence of Aspiration (-) • Incidence of Pneumonia (-)
Groher (1987) RCT (3) N_{start}=66 N_{end}=56 TPS=Chronic	E1: Pureed food + thin liquids E2: Soft mechanical diet + thickened liquids Duration: 6mo	• Incidence of Aspiration Pneumonia (+exp$_2$)
Thick fluids prepared with viscometer vs Thick fluids prepared subjectively		
Goulding & Bakheit (2000) RCT (6) N_{start}=46 N_{end}=46 TPS=Subacute	E: Thickened fluids prepared using a viscometer (lesser viscosity) C: Thickened fluids prepared using subjective assessment (greater viscosity) Duration: Not Reported	• Incidence of Aspiration (-)

Abbreviations and table notes: C=control group; D=days; E=experimental group; H=hours; Min=minutes; RCT=randomized controlled trial; TPS=time post stroke category (Acute: less than 30 days, Subacute: more than 1 month but less than 6 months, Chronic: over 6 months); Wk=weeks.
+exp indicates a statistically significant between groups difference at α=0.05 in favour of the experimental group
+exp$_2$ indicates a statistically significant between groups difference at α=0.05 in favour of the second experimental group
+con indicates a statistically significant between groups difference at α=0.05 in favour of the control group
- indicates no statistically significant between groups differences at α=0.05

Conclusions about dietary modifications

PHARYNGEAL PHASE			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	There is conflicting evidence about the effect of **thick fluid** to improve the pharyngeal phase when compared to **thin fluid.**	2	D Diniz et al., 2009; Garon et al., 1997

RESPIRATORY INFECTIONS			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	There is conflicting evidence about the effect of **thick fluid** to improve respiratory infections when compared to **thin fluid.**	2	Garon et al., 1997; Groher 1987

CALORIE CONSUMPTION			
LoE	**Conclusion Statement**	**RCTs**	**References**
2	**Thick fluid** may not have a difference in efficacy compared to **thin fluid** for improving calorie consumption.	1	Garon et al., 1997

Key Points

There is conflicting evidence on the efficacy of dietary modifications to improve the pharyngeal phase, or respiratory infections.

Swallowing Treatment Programs

Adapted from: https://content.iospress.com/articles/neurorehabilitation/nre172250 & https://www.medicalnewstoday.com/articles/177473.php

Several studies have examined the effect of formal dysphagia therapy on a variety of outcomes. Dysphagia therapy usually involves a combination of approaches, including exercises aimed at strengthening muscles, and improving movement and coordination. Possible modified swallowing strategies may include the Mendelsohn maneuver (the patient holds the larynx up, either using the muscles of the neck or with the hand, during swallow for an extended period of time), the Masako maneuver (patient protrudes tongue and then swallows), shaker exercise and gargling, among others. Other strategies include postural changes (head turn and chin tuck postures) and multiple swallows. These strategies are usually provided in addition to dietary modifications.

Nine RCTs were found evaluating swallowing treatment programs for dysphagia rehabilitation. Three RCTs evaluated expiratory muscle training compared to conventional care or a placebo device (Eom et al., 2017; Moon et al., 2017; Park et al., 2016a). One RCT compared chin tuck resistance exercises to conventional care (Park et al., 2018). One RCT compared shaker exercises to conventional care (Choi et al., 2017). One RCT evaluated tongue pressure profile training compared to tongue pressure strength and accuracy training (Steele et al., 2016). One RCT compared early, middle and late swallowing therapy interventions (Bakhtiyari et al., 2015). Two RCTs compared high intensity swallowing therapy to lower intensity swallowing therapy (Carnaby et al., 2006; DePippo et al., 1994).

The methodological details and results of all nine RCTs are presented in in **Table 15.**

Table 15. RCTs examining swallowing treatment programs for dysphagia

Authors (Year) Study Design (PEDro Score) Sample Size$_{start}$ Sample Size$_{end}$ Time post stroke category	Interventions Duration: Session length, frequency per week for total number of weeks	Outcome Measures Result (direction of effect)
Expiratory muscle training vs conventional care/placebo		
Eom et al. (2017) RCT (5) N_{Start}=33 N_{End}=26 TPS=Subacute	E: Expiratory muscle strength training (25 reps/d) C: Sham Duration: 5x/wk for 4wk	• Videofluroscopic Dysphagia Scale (-) • Penetration-Aspiration scale (+exp)
Moon et al. (2017) RCT (4) N_{Start}=18 N_{End}=18 TPS=Acute	E: Expiratory muscle strength training C: Conventional swallowing therapy Duration: 30min/d, 5x/wk for 4wk	• Functional Dysphagia Scale (+exp) • Vallecular Residue (+exp) • Pyriform Sinuses (+exp) • Penetration-Aspiration Scale (+exp)
Park et al. (2016a) RCT (6) N_{Start}=33 N_{End}=27 TPS=Subacute	E: Expiratory Muscle Strengthening Group using a Device C: Placebo Device Duration: 30min/d, 5d/wk for 4wk	• Liquid Penetration-Aspiration Scale (+exp) • Semisolid Penetration-Aspiration Scale (-) • Functional Oral Intake Scale (+exp) • Suprahyoid muscle activation (+exp)
Chin tuck resistance exercises vs conventional care		
Park et al. (2018) RCT (5) N_{Start}=25 N_{End}=22 TPS=Chronic	E: Chin Tuck Against Resistance Exercise C: Conventional swallowing therapy Duration: 30min/d, 5x/wk for 4wk	• Functional Dysphagia Scale (+exp) • Penetration-Aspiration scale (+exp)
Shaker exercises vs conventional care		
Choi et al. (2017) RCT (4) N_{Start}=31 N_{End}=21 TPS=Subacute	E: Shaker exercise C: Conventional swallowing therapy Duration: 30min/d, 5x/wk for 4wk	• Penetration-Aspiration scale (+exp) • Functional Oral Intake scale (+exp)
Tongue-pressure profile training vs tongue-pressure strength and accuracy training		
Steele et al. (2016) RCT (6) N_{Start}=14 N_{End}=11 TPS=Subacute	E1: Tongue-Pressure Profile Training group E2: Tongue-Pressure Strength and Accuracy Training group Duration: 1hr/d, 3d/wk for 8wk	• Tongue Strength (-) • Stage transition duration (-) • Penetration-Aspiration Scale (-) • Normalized Residue Rating Scale (-)
Early vs Middle vs Late swallowing therapy interventions		
Bakhtiyari et al. (2015) RCT (5) N_{Start}=84 N_{End}=60 TPS=Acute	E1: Early Swallowing Therapy (3d) E2: Medium Swallowing Therapy (2wk) E3: Late Swallowing Therapy (1mo) Duration: 45min/d, 3d/wk for 12wk Statistical Analysis: ANOVA	E1 vs E2/E3 • North-Western Dysphagia patients check sheet (+exp1) • Pneumonia Frequency: (+exp_1)
High intensity swallowing therapy vs low intensity swallowing therapy		
Carnaby et al. (2006) RCT (8) N_{start}=306 N_{end}=280 TPS=Acute	E1: Standard swallowing therapy (low-intensity intervention) E2: Standard swallowing therapy (high-intensity intervention and dietary prescription) C: Usual care Duration: 30min/d, 5d/wk for 4wk	E2 vs E1/C • Proportion of individuals returning to normal diet (+exp2) • Time until return to normal diet (+con) • Swallow recovery (+exp2) • Occurrence of chest infection (+exp2) • Modified Rankin scale (-)
DePippo et al. (1994) RCT (5) N_{start}=115 N_{end}=107	E1: One formal dysphagia treatment session + choice of modified-texture diet E2: One formal dysphagia treatment session + prescribed texture-modified diet	E1 vs. E2 vs E3 • Dehydration (-) • Upper Airway Obstruction (-) • Pneumonia (-)

TPS=Subacute	E3: Daily intervention by speech language pathologist + prescribed diet Duration: 45min for 1d + specific diet 3x/d, 7d/wk for 4wk Statistical Analysis: Independent T Test	• Calorie-nitrogen deficiency (-)

Abbreviations and table notes: C=control group; D=days; E=experimental group; H=hours; Min=minutes; RCT=randomized controlled trial; TPS=time post stroke category (Acute: less than 30 days, Subacute: more than 1 month but less than 6 months, Chronic: over 6 months); Wk=weeks.
+exp indicates a statistically significant between groups difference at α=0.05 in favour of the experimental group
+exp_2 indicates a statistically significant between groups difference at α=0.05 in favour of the second experimental group
+con indicates a statistically significant between groups difference at α=0.05 in favour of the control group
- indicates no statistically significant between groups differences at α=0.05

Conclusions about swallowing treatment programs

PHARYNGEAL PHASE			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Expiratory muscle training** may produce greater improvements in the pharyngeal phase than **conventional care or placebo.**	3	Eom et al., 2017; Moon et al., 2017; Park et al., 2016a
2	**Chin tuck resistance training** may produce greater improvements in the pharyngeal phase than **conventional care.**	1	Park et al., 2018
2	**Shaker exercises** may produce greater improvements in the pharyngeal phase than **conventional care.**	1	Choi et al., 2017
1b	**Tongue-pressure profile training** may not have a difference in efficacy compared to **tongue-pressure strength and accuracy training** for improving the pharyngeal phase.	1	Steele et al., 2016
2	**High intensity swallowing therapy** may not have a difference in efficacy compared to **standard intensity** for improving the pharyngeal phase.	1	DePippo et al., 1994

ORAL PHASE			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Tongue-pressure profile training** may not have a difference in efficacy compared to **tongue-pressure strength and accuracy training** for improving the oral phase.	1	Steele et al., 2016

DYSPHAGIA EVALUATIONS			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	There is conflicting evidence about the effect of **expiratory muscle training** to improve dysphagia evaluations when compared to **conventional care or placebo.**	3	Eom et al., 2017; Moon et al., 2017; Park et al., 2016a
2	**Chin tuck resistance training** may produce greater improvements in dysphagia evaluations than **conventional care.**	1	Park et al., 2018
2	**Shaker exercises** may produce greater improvements in dysphagia evaluations than **conventional care.**	1	Choi et al., 2017
2	**Early swallowing therapy** may produce greater improvements in dysphagia evaluations than **middle or later swallowing therapy.**	1	Bakhityari et al., 2015
1b	There is conflicting evidence about the effect of **high intensity swallowing therapy** to improve dysphagia evaluations when compared to **standard intensity**	1	Carnabay et al., 2006

RESPIRATORY INFECTIONS			
LoE	**Conclusion Statement**	**RCTs**	**References**
2	**Early swallowing therapy** may produce greater improvements in respiratory infections than **middle or later swallowing therapy.**	1	Bakhityari et al., 2015
1b	There is conflicting evidence about the effect of **high intensity swallowing therapy** to improve respiratory infections when compared to **standard intensity**	2	Carnabay et al., 2006; DePippo et al., 1994

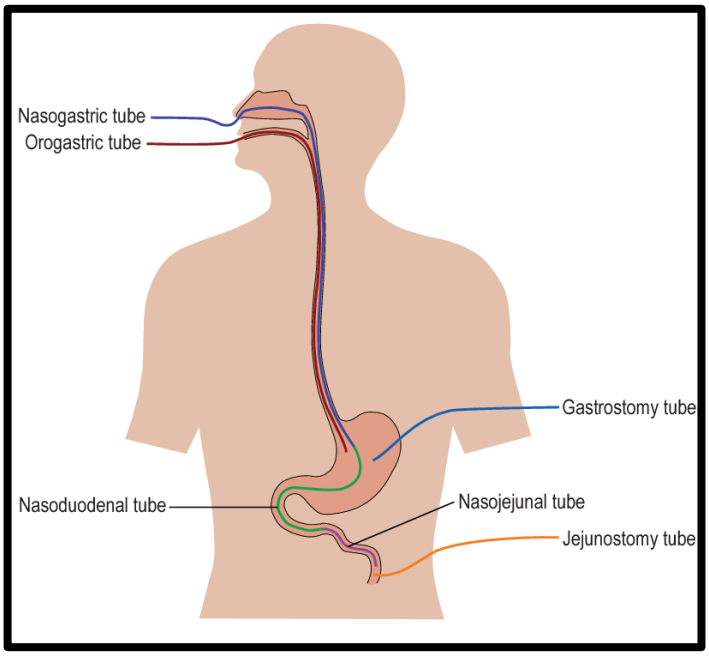
STROKE SEVERITY			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**High intensity swallowing therapy** may not have a difference in efficacy compared to **standard intensity** for improving stroke severity.	1	Carnabay et al., 2006

VITAMIN AND MINERAL CONSUMPTION			
LoE	**Conclusion Statement**	**RCTs**	**References**
2	**High intensity swallowing therapy** may not have a difference in efficacy compared to **standard intensity** for improving vitamin and mineral consumption.	1	DePippo et al., 1994

Key Points

Expiratory muscle training may be beneficial for improving the pharyngeal phase, but there is conflicting evidence for its ability to improve a dysphagia evaluation.

Selection of Feeding Tubes



Adapted from: https://www.semanticscholar.org/paper/Maintaining-adequate-hydration-and-nutrition-in-Dunn/9db3bdb886671906b00b87e0365233f9f2b696f9

Enteral feeding may be required for either brief or prolonged periods of time and is used most commonly in the treatment of dysphagia. As a result, the choice of feeding tube is dictated, in large part, by the anticipated length of swallowing impairment. Broadley et al. (2003) have identified several predictors of prolonged dysphagia, which include initial stroke severity, dysphasia and the involvement of frontal or insular cortex on brain imaging. However, it can be clinically challenging to accurately predict the length of time that enteral feeding will be required. Feeding tubes fall into two broad categories. Nasogastric (NG) tubes, usually intended for short-term use, are positioned directly into the stomach (with extensions into the small bowel) or small intestine through the nose and throat. Alternatively, gastro-enteric tubes are used for long-term feeding and are placed into the stomach percutaneously or surgically. There are advantages and disadvantages to both tube types. Nasogastric tubes have been shown to be less effective with greater side effects compared to gastrostomy tubes for patients that require a longer duration of non-oral feeding (Hull et al., 1993; R. H. Park et al., 1992), although significant mortality and morbidity has been associated with more invasive enteric tubes, such as the percutaneous endoscopic gastrostomy (Anderson et al., 2004).

Six RCTs were found evaluating the selection of feeding tubes for dysphagia rehabilitation. One RCT compared early nasogastric tube feeding to no tube feeding (Zheng et al., 2015). Three RCTs compared gastrotomy tube feeding to nasogastric tube feeding (Dennis et al., 2005b; Norton et al., 1996; Park et al., 1992). One RCT compared a nasogastric tube secured with tape to one secured with a nasal loop (Beaven et al., 2010). One RCT compared early tube intervention to a latter tube intervention (Dennis et al., 2005a).

The methodological details and results of all six RCTs are presented in in **Table 16.**

Table 16. RCTs examining selection of feeding tubes for dysphagia

Authors (Year) Study Design (PEDro Score) Sample Size$_{start}$ Sample Size$_{end}$ Time post stroke category	Interventions Duration: Session length, frequency per week for total number of weeks	Outcome Measures Result (direction of effect)
Early nasogastric tube feeding vs no tube		
Zheng et al. (2015) RCT (6) N_{Start}=146 N_{End}=146 TPS=Acute	E: Early Enteral Feeding (<72hr) C: Family-Managed Nutrition Duration: Both interventions started within 72hr and lasted 10d (consecutive)	• Infection rate (+exp) • Triceps skinfold (+exp) • Arm muscle circumference (+exp) • Hemoglobin (+exp) • Albumin (+exp) • Triglyceride (+exp)
Gastrotomy tube vs nasogastric tube		
Dennis et al. (2005b) RCT (7) N_{start}=321 N_{end}=321 TPS=Acute Note : Study 2 of 2 from publication	E1: Percutaneous endoscopic gastrostomy tube E2: Nasogastric tube Duration: 24hr/d, 7d/wk for 4wk	• Incidence of pneumonia: (-)
Norton et al. (1996) RCT (6) N_{start}=30 N_{end}=30 TPS=Acute	E1: Gastrostomy tube E2: Nasogastric tube Duration: 24hr/d, 7d/wk for 6wk	• Weight gain (+exp1) • Hemoglobin (-) • Albumin (+exp1) • Mid-arm circumference (+exp1)
Park et al. (1992) RCT (6) N_{start}=40 N_{end}=38 TPS=Subacute	E1: Gastrostomy tube E2: Nasogastric tube Duration: 4wks Statistical Analysis: ANOVA	• Proportion of prescribed feed delivered: (+exp$_1$) • Weight gain: (+exp$_1$)
Tape secured nasogastric tube vs nasal loop secured nasogastric tube		
Beavan et al. (2010) RCT (7) N_{start}=104 N_{end}=97 TPS=Acute	E1: Adhesive tape secured nasogastric tube E2: Nasal loop secured nasogastric tube Duration: <3mo	• Proportion of prescribed feed delivered: (+exp$_2$) • Barthel Index (-)
Early tube intervention vs later tube intervention		
Dennis et al. (2005a) RCT (7) N_{start}=859 N_{end}=858 TPS=Acute Note : Study 1 of 2 from publication	E1: early tube intervention (<7 days post- stroke) E2: late tube intervention (>7 days post-stroke Duration: 24hr/d, 7d/wk for 4wk	• Incidence of pneumonia: (-)

Abbreviations and table notes: C=control group; D=days; E=experimental group; H=hours; Min=minutes; RCT=randomized controlled trial; TPS=time post stroke category (Acute: less than 30 days, Subacute: more than 1 month but less than 6 months, Chronic: over 6 months); Wk=weeks.
+exp indicates a statistically significant between groups difference at α=0.05 in favour of the experimental group
+exp$_2$ indicates a statistically significant between groups difference at α=0.05 in favour of the second experimental group
+con indicates a statistically significant between groups difference at α=0.05 in favour of the control group
- indicates no statistically significant between groups differences at α=0.05

Conclusions about the selection of feeding tubes

RESPIRATORY INFECTIONS			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Early nasogastric tube feeding** may produce greater improvements in respiratory infections than **no tube feeding.**	1	Zheng et al., 2015
1b	**Gastronomy tubes** may not have a difference in efficacy compared to **nasogastric tubes** for improving respiratory infections.	1	Dennis et al., 2005b
1b	**Early tube feeding** may not have a difference in efficacy compared to **late tube feeding** for improving respiratory infections.	1	Dennis et al., 2005a

ACTIVITIES OF DAILY LIVING			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Nasogastric tubes secured by a nasal loop** may not have a difference in efficacy compared **nasogastric tubes secured with tape** for improving activities of daily living.	1	Beaven et al., 2010

LIPID CONSUMPTION			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Early nasogastric tube feeding** may produce greater improvements in lipid consumption than **no tube feeding.**	1	Zheng et al., 2015

CALORIE CONSUMPTION			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Gastronomy tubes** may produce greater improvements in calorie consumption than **nasogastric tubes.**	1	Park et al., 1992
1b	**Nasogastric tubes secured by a nasal loop** may produce greater improvements in calorie consumption than **nasogastric tubes secured with tape.**	1	Beaven et al., 2010

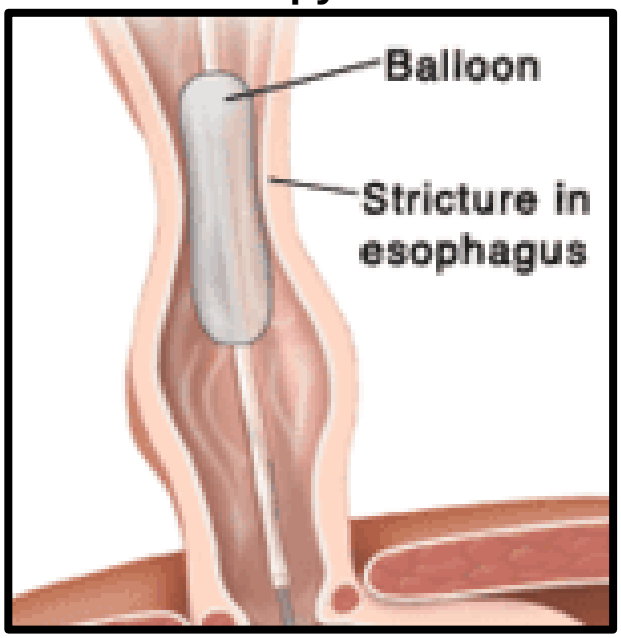
BODY COMPOSITION			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Early nasogastric tube feeding** may produce greater improvements in body composition than **no tube feeding.**	1	Zheng et al., 2015
1a	**Gastronomy tubes** may produce greater improvements in body composition than **nasogastric tubes**	2	Norton et al., 1996; Park et al., 1992

PLASMA PROTEINS			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Early nasogastric tube feeding** may produce greater improvements in plasma protein levels than **no tube feeding.**	1	Zheng et al., 2015
1b	There is conflicting evidence about the effect of **gastronomy tubes** to improve plasma protein levels when compared to **a nasogastric tube.**	1	Norton et al., 1996

Key Points

Gastronomy tube feeding may be more beneficial than nasogastric tubes for improving body composition and calorie consumption but not respiratory infections.

Balloon Therapy



Adapted from: https://www.midwestgihealth.com/esophageal-dilation

Oropharyngeal dysfunction can manifest in a number of different ways depending on which part of swallowing apparatus is affected, and when. One common finding in dysphagia is a narrowing of the upper esophageal sphincter (UES). Balloon dilation therapy is a method whereby a small deflated balloon is interested into the upper esophagus, inflated, and then used to stretch out the UES as it is pulled back into the oral cavity with or without swallowing (Wei et al., 2017). It has been used successfully in non-stroke related swallowing dysfunction but its effectiveness for dysphagia therapy in a stroke population has only recently been investigated.

One RCT was found evaluating balloon therapy for dysphagia rehabilitation. It compared a modified balloon dilatation therapy to conventional swallowing therapy (Wei et al., 2017).

The methodological details and results of the single RCT are presented in in **Table 17.**

Table 17. RCTs examining balloon therapy for dysphagia

Authors (Year) Study Design (PEDro Score) Sample Size$_{start}$ Sample Size$_{end}$ Time post stroke category	Interventions Duration: Session length, frequency per week for total number of weeks	Outcome Measures Result (direction of effect)
Wei et al. (2017) RCT (5) N_{Start}=30 N_{End}=30 TPS=Subacute	E: Modified Balloon Dilatation Therapy C: Conventional swallowing therapy Duration: 30min/session, 5 to 8 sessions, 5x/wk for 2 to 3wk.	• Tube dependence (+exp) • Functional Oral Intake Scale (+exp) • Videofluroscopy Swallowing Study (+exp)

Abbreviations and table notes: C=control group; D=days; E=experimental group; H=hours; Min=minutes; RCT=randomized controlled trial; TPS=time post stroke category (Acute: less than 30 days, Subacute: more than 1 month but less than 6 months, Chronic: over 6 months); Wk=weeks.
+exp indicates a statistically significant between groups difference at α=0.05 in favour of the experimental group
+exp$_2$ indicates a statistically significant between groups difference at α=0.05 in favour of the second experimental group
+con indicates a statistically significant between groups difference at α=0.05 in favour of the control group
- indicates no statistically significant between groups differences at α=0.05

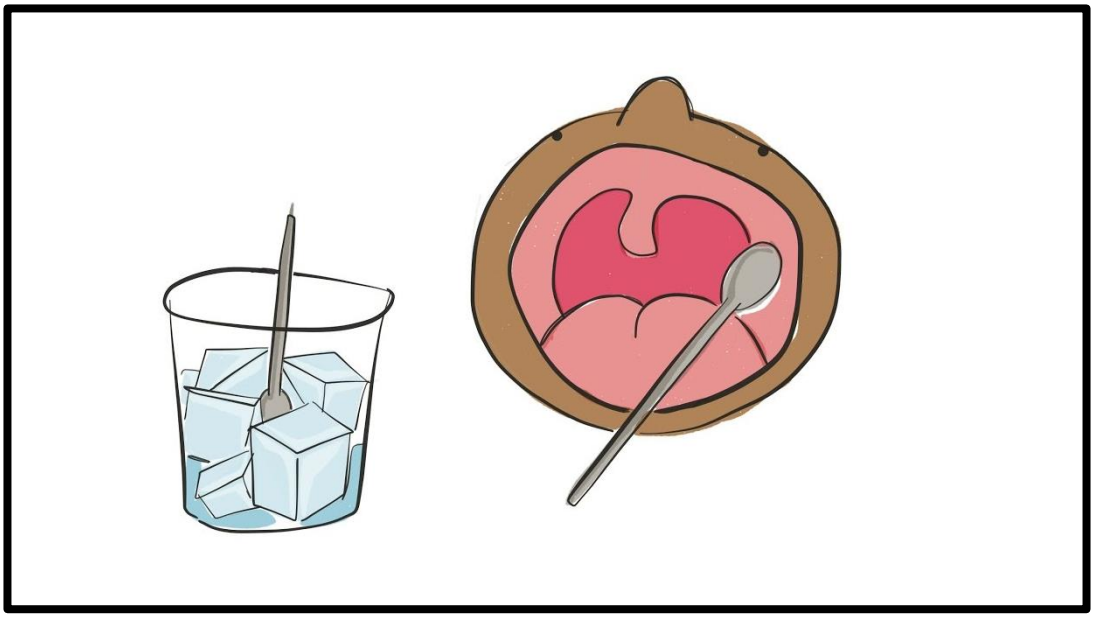
Conclusions about balloon therapy

DYSPHAGIA EVALUATIONS			
LoE	**Conclusion Statement**	**RCTs**	**References**
2	**Balloon therapy** may produce greater improvements in dysphagia evaluations than **conventional swallowing therapy.**	1	Wei et al., 2017

Key Points

Balloon dilation therapy may be beneficial for improving dysphagia evaluations.

Thermal Stimulation



Adapted from: https://www.youtube.com/watch?v=ukfdL7FNxJo

Thermal stimulation is a different, less invasive form of external stimulation designed to improve swallowing. For thermal stimulation, a cold stimulus is generally applied the anterior faucial pillar prior to the individual swallowing. This is believed that both the tactile and thermal stimuli will increase oral awareness and can improve the transition from the initiated oral phase to the involuntary pharyngeal phase (Malik et al., 2017).

Five RCTs were found evaluating thermal stimulation for dysphagia rehabilitation. Two RCTs compared thermal stimulation to no stimulation or conventional care (Li et al., 2017; Nakamura & Fujishima, 2013). One RCT compared thermal tactile stimulation to suprahyoid and infrahyoid NMES (Byeon & Koh, 2016b). One RCT compared thermal tactile stimulation with NMES to thermal tactile stimulation alone (Lim et al., 2009). One RCT compared four varying levels of thermal tactile stimulation therapy (Rosenbek et al., 1998).

The methodological details and results of all five RCTs are presented in in **Table 18.**

Table 18. RCTs examining thermal stimulation for dysphagia

Authors (Year) Study Design (PEDro Score) Sample Size$_{start}$ Sample Size$_{end}$ Time post stroke category	Interventions Duration: Session length, frequency per week for total number of weeks	Outcome Measures Result (direction of effect)
Thermal Stimulation vs Conventional care/no stimulation		
Li et al. (2017) RCT (4) N_{Start}=40 N_{End}=40 TPS=Not Reported (Acute)	E: Ice-swab swallowing training C: Conventional swallowing therapy Duration: 20min per session, 3x/d	• Kubota Water Test (-)
Nakamura & Fujishima (2013) RCT Cross-Over (6) N_{start}=24 N_{end}=21 TPS=NR Note: Analysis performed on 'responders' only (14/24)	E: Ice massage C: No Ice massage Duration: 10min/d (3x/d), 5d/wk for 2wk Statistical Analysis: Wilcoxon-Signed Rank Test	Patients able to initiate the swallow reflex: • Latency (+exp)
Thermal Tactile Stimulation vs Suprahyoid and Infrahyoid NMES		
Byeon & Koh (2016b) RCT (6) N_{Start}=45 N_{End}=45 TPS=Subacute	E1: NMES (mylohyoid and thyrohyoid) E2: Thermal Tactile Oral Stimulation Duration: 30min/d, 5d/wk for 3wk	• Videofluoroscopic Swallowing Study (-)
NMES + Thermal Tactile Stimulation vs Thermal Tactile Stimulation		

Lim et al. (2009)
RCT (3)
N_{start}=36
N_{end}=28
TPS=Subacute (mostly)/Chronic
	E: Thermal- tactile stimulation + NMES
	C: Thermal-tactile stimulation
	Duration: 30min/d 5d/wk for 4wk of thermal tactile + 30min/d, 5d/wk for 4wk of NMES
		• Swallow function scoring system: (+exp)
		• Penetration-aspiration scale
		  ○ Semi solid (+exp)
		  ○ Liquid (+exp)
		• Pharyngeal transit time
		  ○ Semi solid (+exp)
		  ○ Liquid (+exp)

Higher intensities of stimulation vs lower intensities		
Rosenbek et al. (1998) RCT (5) N_{start}=45 N_{end}=43 TPS=Subacute	E1: 150 trials/wk of tactile-thermal stimulation E2: 300 trials/wk of tactile-thermal stimulation E3: 450 trials/wk of tactile-thermal stimulation E4: 600 trials/wk of tactile-thermal stimulation Duration: Trials spread over 5d/wk for 2wk Statistical Analysis: Mann-Whitney U Test	• Duration of stage transition (3ml liquid) (-) • Duration of stage transition (10ml liquid) (-) • Penetration/aspiration (3ml liquid) (-) • Penetration/aspiration (10ml liquid) (-)

Abbreviations and table notes: C=control group; D=days; E=experimental group; H=hours; Min=minutes; RCT=randomized controlled trial; TPS=time post stroke category (Acute: less than 30 days, Subacute: more than 1 month but less than 6 months, Chronic: over 6 months); Wk=weeks.
+exp indicates a statistically significant between groups difference at α=0.05 in favour of the experimental group
+exp$_2$ indicates a statistically significant between groups difference at α=0.05 in favour of the second experimental group
+con indicates a statistically significant between groups difference at α=0.05 in favour of the control group
- indicates no statistically significant between groups differences at α=0.05 \

Conclusions about thermal stimulation

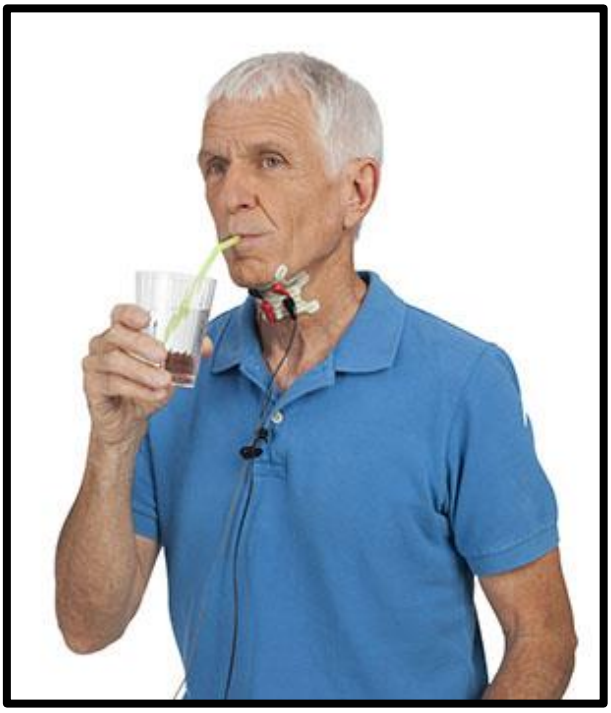
PHARYNGEAL PHASE			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Thermal stimulation** may produce greater improvements in the pharyngeal phase than **conventional care or no thermal stimulation.**	1	Nakamura & Fujishima, 2013
2	**Thermal stimulation with NMES** may produce greater improvements in the pharyngeal phase than **thermal stimulation alone.**	1	Lim et al., 2009
2	**Higher intensities of thermal stimulation therapy** may not have a difference in efficacy compared to **lower intensities of thermal stimulation therapy** for improving the pharyngeal phase.	1	Rosenbek et al., 1998

DYSPHAGIA EVALUATIONS			
LoE	**Conclusion Statement**	**RCTs**	**References**
2	**Thermal stimulation** may not have a difference in efficacy compared to **conventional care or no thermal stimulation** for improving a dysphagia evaluation.	1	Li et al., 2017
1b	**Thermal stimulation** may not have a difference in efficacy compared to **NMES** for improving a dysphagia evaluation.	1	Byeon & Koh, 2016
2	**Thermal stimulation with NMES** may produce greater improvements in a dysphagia evaluation than **thermal stimulation alone.**	1	Lim et al., 2009

Key Points

Thermal stimulation with NMES may be more beneficial than thermal stimulation alone for improving the pharyngeal phase, and dysphagia evaluations.

Neuromuscular Electrical Stimulation (NMES)



Adapted from: https://www.dioglobal.eu/en_UK/Dysphagia_How_to_Tackle_the_Difficult_Pill_to_Swallow.html

In the past, dysphagia therapy has focussed on behavioural compensatory strategies. While improving swallowing safety, these methods are limited in their ability to increase mechanical function and recover neural swallowing pathways (Kushner et al., 2013; Rofes et al., 2013). Recently, a new method of therapy has emerged. Transcutaneous electrical stimulation or neuromuscular electrical stimulation (NMES) focuses on peripheral stimulation of the oropharyngeal muscles to enhance neuroplasticity and recovery of swallowing function (Jayasekeran et al., 2010). It involves the administration of small electrical impulses to the muscles associated with swallowing in the throat through electrodes attached to the skin and is usually used in addition to conventional swallowing therapy. NMES results in greater muscular recovery than voluntary contraction due to recruiting a larger proportion of motor units (Sun et al., 2013).

Thirteen RCTs were found evaluating NMES for dysphagia rehabilitation. Four RCTs compare suprahyoid NMES to conventional care or sham (Konecny et al., 2018; Guillen-Sola et al., 2017; Zhang et al., 2016; Lee et al., 2014). Three RCTs compared infrahyoid NMES to conventional care (Huang et al., 2014; Permsirivanich et al., 2009; Bulow et al., 2008). Two RCTs compared suprahyoid and infrahyoid NMES to conventional care (El-Tamawy et al., 2015; Xia et al., 2011). Two RCTs compared suprahyoid and infrahyoid NMES to suprahyoid NMES alone (Meng et al., 2018; Nam et al., 2013). One RCT compared masseter NMES to a sham stimulation (Umay et al., 2018). One RCT compared anterior faucial pillar NMES to sham stimulation (Power et al., 2006).

The methodological details and results of all 13 RCTs are presented in in **Table 19.**

Table 19. RCTs examining NMES for dysphagia

Authors (Year) Study Design (PEDro Score) Sample Size$_{start}$ Sample Size$_{end}$ Time post stroke category	Interventions Duration: Session length, frequency per week for total number of weeks	Outcome Measures Result (direction of effect)
Suprahyoid NMES vs Conventional care/sham		
Konecny et al. (2018) RCT (4) N_{Start}=108 N_{End}=108 TPS=Not Reported	E: NMES (60Hz, 300ms pulse length) to the suprahyoid muscle C: Conventional swallowing therapy Duration: 20min/d, 5d/wk for 4wk	• Oral transit time (+exp) • Pharyngeal transit time (+exp)
Guillen-Sola et al. (2017) RCT (6) N_{Start}=62 N_{End}=50 TPS=Acute	E1: NMES (suprahyoid) + Sham Expiratory muscle strength training + Conventional swallowing therapy E2: Expiratory muscle strength training + Conventional swallowing therapy C: Conventional swallowing therapy Duration: 30min/d, 5x/wk for 4wk	E1/E2 vs C • Penetration-Aspiration Scale (-) • Volume Viscosity Swallow Test (-) • Functional Oral Intake Scale (-) • Dysphagia Outcome Severity Scale (-)
Zhang et al. (2016) RCT (5) N_{Start}=82 N_{End}=82 TPS=Acute	E1: Sensory NMES + Swallowing training E2: Motor NMES (Suprahyoid) + Swallowing training C: Swallowing training Duration: 20min/d (2x/d), 5d/wk for 4wk Statistical Analysis: ANOVA	E1 vs C • Standardized Swallowing Assessment: (+exp$_1$) • Functional Oral Intake Scale: (+exp$_1$) • Water swallow test (exp1) E2 vs C • Standardized Swallowing Assessment: (+exp$_2$) • Functional Oral Intake Scale: (+exp$_2$) • Water swallow test (+exp$_2$) E1 vs E2 • Standardized Swallowing Assessment: (+exp$_1$) • Functional Oral Intake Scale: (+exp$_1$) • Water swallow test (exp1)
Lee et al. (2014) RCT (4) N_{Start}=57 N_{End}=57 TPS=Acute	E: NMES (Suprahyoid) + traditional dysphagia therapy C: Traditional dysphagia therapy Duration: 30min/d, 5d/wk for 3wk Statistical Analysis: Wilcoxon-Signed Rank Test	• Functional oral intake scale: (+exp)
Infrahyoid NMES vs conventional care		

Huang et al. (2014)
RCT (7)
N_{Start}=29
N_{End}=29
TPS=Acute
	E1: NMES (infrahyoid)
	E2: NMES + Traditional Swallowing Therapy (TST)
	C: Traditional Swallowing Therapy
	Duration: 60min/d, 3d/wk for 4wk
	Statistical Analysis: ANOVA
		E1 vs E2 vs C
		• Functional dysphagia scale: (-)
		  ○ Soft diet (-)
		  ○ Cookie diet (exp2)
		  ○ Thick fluid (+exp2)
		  ○ Thin fluid (-)
		• 8-point penetration-aspiration scale (-)
		Functional oral intake scale (-)

Permsirivanich et al. (2009) RCT (6) N_{start}=28 N_{end}=23 TPS=Acute	E: NMES (thyrohyoid muscle) C: Rehabilitation swallowing therapy Duration: 1hr/d, 5d/wk for 4wk Statistical Analysis: ANOVA	• Functional oral intake scale: (+exp)
Bülow et al. (2008) RCT (3) N_{start}=25 N_{end}=25 TPS=Subacute/Chronic	E: NMES (thyrohyoid muscle) C: Traditional swallowing therapy Duration: 30min/d, 5d/wk for 3wk Statistical Analysis: Independent T-Tests	• Videoradiographic swallowing evaluation (-) • Actual Nutrition Status (-) • Oral motor function test (-)
Suprahyoid and infrahyoid NMES vs conventional care		

El-Tamawy et al. (2015) RCT (5) N_{Start}=30 N_{End}=30 TPS=Acute	E: Additional Physical Therapy + NMES (suprahyoid + infrahyoid) C: No Additional Treatment Duration: 45min/d, 3d/wk for 6wk of physical therapy + 30min/d, 3d/wk for 6wk NMES	• Esophageal Sphincter Function (-) • Oral Transit Time (+exp) • Aspiration-Penetration Rate (+exp) • Hyoid Elevation (+exp) • Laryngeal Elevation (+exp)
Xia et al. (2011) RCT (4) N_{start}=120 N_{end}=107 TPS=Chronic	E1: NMES (VitalStim) (Hyoid Bone Muscles) E2: NMES with conventional swallowing therapy C: Conventional swallowing therapy Duration: 30min/d, 5d/wk for 4wk Statistical Analysis: ANOVA	E1 vs E2 • Standardized swallowing assessment: ($+exp_2$) • EMG of swallowing muscles (+exp2) • Videofluoroscopic Swallowing Study ($+exp_2$) E2 vs C • Standardized swallowing assessment: ($+exp_2$) • EMG of swallowing muscles (+exp2) • Videofluoroscopic Swallowing Study ($+exp_2$)
Suprahyoid and Infrahyoid NMES vs Suprahyoid NMES		
Meng et al. (2018) RCT (5) N_{Start}=30 N_{End}=26 TPS=Acute	E1: NMES on the suprahyoid and infrahyoid E2: NMES on the suprahyoid C: Conventional swallowing therapy Duration: 30min/d, 5x/wk for 2wk	E1 vs E2 • Water Swallow Test (-) • Repetitive Saliva Swallowing Test (-) • Dysphagia Outcome Severity Scale (-) E1/E2 vs C • Water Swallow Test (+exp1,+exp2) • Repetitive Saliva Swallowing Test (+exp1,+exp2) • Dysphagia Outcome Severity Scale (+exp1,+exp2)
Nam et al. (2013) RCT (7) N_{Start}=66 N_{End}=50 TPS=Subacute	E1: Hyolaryngeal electrical stimulation on the suprahyoid muscle E2: Hyolaryngeal electrical stimulation on the suprahyoid and infrahyoid muscles Duration: 45min/d, 5d/wk for 3wk Statistical Analysis: ANOVA	• Maximal anterior hyoid excursion distance (-) • Maximal anterior velocity of the hyoid excursion (-) • Maximal superior laryngeal elevation distance (-)
Masseter NMES vs sham stimulation		
Umay et al. (2018) RCT (6) N_{Start}=98 N_{End}=98 TPS=Acute	E: NMES bilaterally to the masseter muscles C: Sham Duration: 60min/d, 5x/wk for 4wk	• Water Swallow Test (+exp) • Neurological Examination Dysphagia Scores (+exp) • Mann Assessment of Swallowing Ability Test (+exp) • Flexible Fibreoptic Endoscopic Evaluation of Swallowing (+exp) • Functional Independence Measure (+exp)
Anterior Faucial Pillar NMES vs Sham stimulation		
Power et al. (2006) RCT (4) N_{start}=16 N_{end}=14 TPS=Acute	E: NMES to the anterior faucial pillar C: Sham stimulation Duration: 10min/d (5min per side), 5d/wk for 2wk Statistical Analysis: Mann Whitney U Test	• Pharyngeal transit time (-) • Oral Transit Time (-) • Swallow Response Time (-) • Laryngeal Closure Duration (-) • Cricopharyngeal Opening Duration (-) • Aspiration severity (-)

Abbreviations and table notes: C=control group; D=days; E=experimental group; H=hours; Min=minutes; RCT=randomized controlled trial; TPS=time post stroke category (Acute: less than 30 days, Subacute: more than 1 month but less than 6 months, Chronic: over 6 months); Wk=weeks.
+exp indicates a statistically significant between groups difference at α=0.05 in favour of the experimental group
$+exp_2$ indicates a statistically significant between groups difference at α=0.05 in favour of the second experimental group
+con indicates a statistically significant between groups difference at α=0.05 in favour of the control group
- indicates no statistically significant between groups differences at α=0.05

Conclusions about NMES

PHARYNGEAL PHASE			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	There is conflicting evidence about the effect of **suprahyoid NMES** to improve the pharyngeal phase when compared to **conventional care or sham.**	2	Guillen-Sola et al., 2017; Konecny et al., 2018
1b	**Infrahyoid NMES** may not have a difference in efficacy compared to **conventional therapy** for improving the pharyngeal phase.	2	Huang et al., 2014; Bulow et al., 2008
2	**Suprahyoid and infrahyoid NMES** may produce greater improvements in the pharyngeal phase than **conventional care or sham.**	1	El Tamaway et al., 2015
2	**Suprahyoid and infrahyoid NMES** may not have a difference in efficacy compared to **suprahyoid NMES alone** for improving the pharyngeal phase.	1	Nam et al., 2013
2	**Anterior faucial pillar NMES** may not have a difference in efficacy compared to **a sham** for improving the pharyngeal phase.	1	Power et al., 2006

ESOPHOGEAL PHASE			
LoE	**Conclusion Statement**	**RCTs**	**References**
2	**Suprahyoid and infrahyoid NMES** may not have a difference in efficacy compared to **conventional care or sham** for improving the esophageal phase.	1	El Tamaway et al., 2015
2	**Anterior faucial pillar NMES** may not have a difference in efficacy compared to **a sham** for improving the esophageal phase.	1	Power et al., 2006

ORAL PHASE			
LoE	**Conclusion Statement**	**RCTs**	**References**
2	**Suprahyoid NMES** may produce greater improvements in the oral phase than **conventional care or sham.**	1	Konecny et al., 2018
2	**Infrahyoid NMES** may not have a difference in efficacy compared to **conventional therapy** for improving the oral phase.	1	Bulow et al., 2008
2	**Suprahyoid and infrahyoid NMES** may produce greater improvements in the oral phase than **conventional care or sham.**	1	El Tamaway et al., 2015
2	**Anterior faucial pillar NMES** may not have a difference in efficacy compared to **a sham** for improving the oral phase.	1	Power et al., 2006

DYSPHAGIA EVALUATIONS			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Suprahyoid NMES** may produce greater improvements in a dysphagia evaluation than **conventional care or sham.**	4	Meng et al., 2018; Guillen-Sola et al., 2017; Zhang et al., 2016; Lee et al., 2014
2	**Sensory NMES** may produce greater improvements in a dysphagia evaluation than **motor NMES**	1	Zhang et al., 2016
1a	**Infrahyoid NMES** may not have a difference in efficacy compared to **conventional therapy** for improving a dysphagia evaluation.	3	Huang et al., 2014; Permsirivanich et al., 2009; Bulow et al., 2008
1b	**Suprahyoid and infrahyoid NMES** may produce greater improvements in a dysphagia evaluation than **conventional care or sham.**	2	Meng et al., 2018; Xia et al., 2011
2	**Suprahyoid and infrahyoid NMES** may not have a difference in efficacy compared to **suprahyoid NMES alone** for improving a dysphagia evaluation.	1	Meng et al., 2018
1b	**Masseter NMES** may produce greater improvements in a dysphagia evaluation than **a sham.**	1	Umay et al., 2018

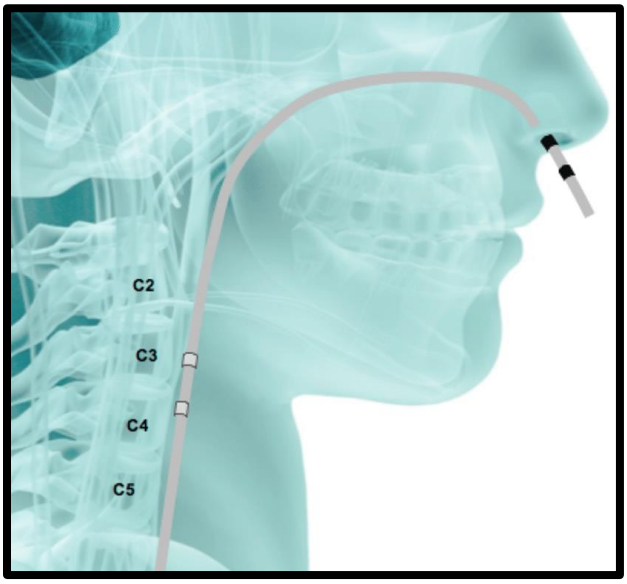
ACTIVITIES OF DAILY LIVING			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Masseter NMES** may produce greater improvements in activities of daily living than **a sham.**	1	Umay et al., 2018

Key Points

Suprahyoid, or suprahyoid with infrahyoid NMES may be beneficial for improving the pharyngeal phase, oral phase and dysphagia evaluations.

Infrahyoid NMES alone may not be beneficial for improving dysphagia related outcomes.

Pharyngeal Electrical Stimulation (PES)



Adapted from: https://www.researchgate.net/figure/The-transit-of-the-electrode-for-pharyngeal-stimulation-from-the-site-of-introduction-to_fig1_322248317

As the neurophysiology of swallowing becomes more clear, there are a growing number of interventions designed around these insights. One such intervention is pharyngeal electrical stimulation (PES). Studies have shown that an increase in corticopharyngeal excitability is associated with recovery of swallowing post-stroke (Mihai et al., 2014). The swallowing areas of the brain (nucleus tractus solitarus, NTS) are highly innervated by afferent connections of the oral, pharyngeal and laryngeal mucosa. It is believed that by stimulating the sensory fibers inside of the mucosa, PES will stimulate the NTS and drive cortical rearrangement as these inputs are transmitted to higher brain areas (Restivo & Hamdy, 20180.

Three RCTs were found evaluating PES for dysphagia rehabilitation. All three RCTs compared PES to sham stimulation (Bath et al., 2016; Vasant et al., 2016; Jayasekeran et al., 2010).

The methodological details and results of all three RCTs are presented in in **Table 20.**

Table 20. RCTs examining PES for dysphagia

Authors (Year) Study Design (PEDro Score) Sample Size$_{start}$ Sample Size$_{end}$ Time post stroke category	Interventions Duration: Session length, frequency per week for total number of weeks	Outcome Measures Result (direction of effect)
Pharyngeal electric stimulation vs sham stimulation		
Bath et al. (2016) RCT (7) N_{Start}=162 N_{End}=121 TPS=Chronic	E: Pharyngeal Electrical Stimulation C: Sham Stimulation Duration: 30min/d, 5d/wk for 4wk (max)	• Penetration-Aspiration Scale (-) • Barthel Index (-) • Weight (-) • Mid arm circumference (-) • Albumin (-) • Chest infection (-)
Vasant et al. (2016) RCT (7) N_{Start}=36 N_{End}=33 TPS=Acute	E: Pharyngeal Electrical Stimulation C: Sham Stimulation Duration: 10min/d, 3d/wk for 1wk at 5Hz	• Dysphagia Severity Rating: (-) • Penetration-Aspiration Scale: (-) • Feeding Tube Removal (-)
Jayasekeran et al. (2010) RCT (8) N_{start}=31 N_{end}=28 TPS=Acute	E: Pharyngeal electrical stimulation C: Sham stimulation Duration: 30min/d, 3d (consecutive) for 1wk	• Penetration-Aspiration Scale (+exp) • Swallowing Time (-) • Dysphagia severity rating scale (+exp)

Abbreviations and table notes: C=control group; D=days; E=experimental group; H=hours; Min=minutes; RCT=randomized controlled trial; TPS=time post stroke category (Acute: less than 30 days, Subacute: more than 1 month but less than 6 months, Chronic: over 6 months); Wk=weeks.
+exp indicates a statistically significant between groups difference at α=0.05 in favour of the experimental group
+exp$_2$ indicates a statistically significant between groups difference at α=0.05 in favour of the second experimental group
+con indicates a statistically significant between groups difference at α=0.05 in favour of the control group
- indicates no statistically significant between groups differences at α=0.05

Conclusions about PES

PHARYNGEAL PHASE			
LoE	**Conclusion Statement**	**RCTs**	**References**
1a	**Pharyngeal electrical stimulation** may not have a difference in efficacy compared to **a sham stimulation** for improving the pharyngeal phase.	3	Bath et al., 2016; Vasant et al., 2016; Jayasekeran et al., 2010

DYSPHAGIA EVALUATIONS			
LoE	**Conclusion Statement**	**RCTs**	**References**
1a	**Pharyngeal electrical stimulation** may not have a difference in efficacy compared to **a sham stimulation** for improving a dysphagia evaluation.	2	Vasant et al., 2016; Jayasekeran et al., 2010

RESPIRATORY INFECTIONS			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Pharyngeal electrical stimulation** may not have a difference in efficacy compared to **a sham stimulation** for improving respiratory infections.	1	Bath et al., 2016;

ACTIVITIES OF DAILY LIVING			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Pharyngeal electrical stimulation** may not have a difference in efficacy compared to **a sham stimulation** for improving activities of daily living.	1	Bath et al., 2016;

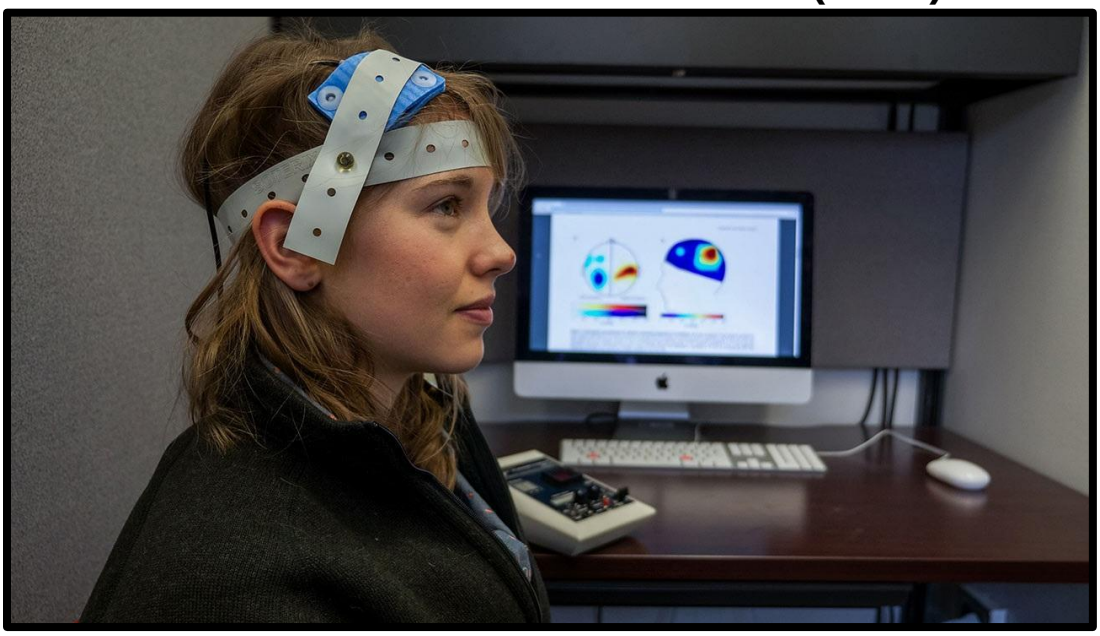
BODY COMPOSITION			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Pharyngeal electrical stimulation** may not have a difference in efficacy compared to **a sham stimulation** for improving body composition.	1	Bath et al., 2016;

PLASMA PROTEINS			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Pharyngeal electrical stimulation** may not have a difference in efficacy compared to **a sham stimulation** for improving plasma protein levels	1	Bath et al., 2016;

Key Points

Pharyngeal electrical stimulation may not be beneficial for improving he pharyngeal phase, or dysphagia evaluations.

Transcranial Direct Current Stimulation (tDCS)



Adapted from: https://www.sciencemag.org/news/2016/02/brain-zapping-therapies-might-be-hitting-lefties-wrong-side-head

Transcranial direct current stimulation (tDCS) has been largely employed in motor trials to evaluated it's efficacy at improving post-stroke impairments of the upper or lower limbs, with some positive findings associated with its use. Recently, the use of non-invasive brain stimulation has quickly gained popularity among clinicians with potential benefits for ameliorating dysphagia post stroke (Langdon & Blacker, 2010). This method of neurostimulation uses a constant low current applied peripherally via electrodes to stimulate the affected brain area.

Four RCTs were found evaluating tDCS for dysphagia rehabilitation. Two RCTs compared contralesional anodal tDCS to sham stimulation (Suntrup-Krueger et al., 2018; Kumar et al., 2011). Two RCTs also compared ipsilesional anodal tDCS to sham stimulation (Shigematsu et al., 2013; Yang et al., 2012).

The methodological details and results of all four RCTs are presented in in **Table 21.**

Table 21. RCTs examining tDCS for dysphagia

Authors (Year) Study Design (PEDro Score) Sample Size$_{start}$ Sample Size$_{end}$ Time post stroke category	Interventions Duration: Session length, frequency per week for total number of weeks	Outcome Measures Result (direction of effect)
Contralesional anodal tDCS vs sham stimulation		
Suntrup-Krueger et al. (2018) RCT (5) N_{Start}=60 N_{End}=59 TPS=Acute	E: Anodal tDCS (1mA contralesional) C: Sham tDCS Duration: 20min/d for 4d	• Fiberoptic Dysphagia Severity Scale (+exp) • Dysphagia Severity Rating Scale (+exp) • Functional Oral Intake Scale (+exp) • Dysphagia Limit Test (+exp) • Pneumonia incidence (-)
Kumar et al. (2011) RCT (7) N_{start}=14 N_{end}=14 TPS=Acute	E: Anodal transcranial direct current stimulation (contralesional) C: Sham stimulation Duration: 45min/d, 5d/wk for 2wk Statistical Analysis: ANOVA	• Dysphagia Outcome and Severity Scale: (+exp) •
Ipsilesional anodal tDCS vs sham stimulation		
Shigematsu et al. (2013) RCT (7) N_{Start}=20 N_{End}=20 TPS=Subacute	E: Anodal Transcranial direct current stimulation (ipsilesional) C: Sham stimulation Duration: 20min/d, 5d/wk for 2wk Statistical Analysis: ANOVA	• Dysphagia Outcome and Severity scale: (+exp)
Yang et al. (2012) RCT (8) N_{start}=16 N_{end}=14 TPS=Acute	E: Anodal Transcranial direct current stimulation (ipsilesional) C: Sham stimulation Duration: 20min/d, 5d/wk for 2wk Statistical Analysis: ANOVA	• Functional dysphagia scale: (-) • Total transit time (-) • Oral transit time (-) • Pharyngeal transit time (-)

Abbreviations and table notes: C=control group; D=days; E=experimental group; H=hours; Min=minutes; RCT=randomized controlled trial; TPS=time post stroke category (Acute: less than 30 days, Subacute: more than 1 month but less than 6 months, Chronic: over 6 months); Wk=weeks.
+exp indicates a statistically significant between groups difference at α=0.05 in favour of the experimental group
+exp$_2$ indicates a statistically significant between groups difference at α=0.05 in favour of the second experimental group
+con indicates a statistically significant between groups difference at α=0.05 in favour of the control group
- indicates no statistically significant between groups differences at α=0.05

Conclusions about tDCS

PHARYNGEAL PHASE			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Ipsilesional anodal tDCS** may not have a difference in efficacy compared to **sham stimulation** for improving the pharyngeal phase.	1	Yang et al., 2012

ORAL PHASE			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Ipsilesional anodal tDCS** may not have a difference in efficacy compared to **sham stimulation** for improving the oral phase.	1	Yang et al., 2012

DYSPHAGIA EVALUATIONS			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Contralesional anodal tDCS** may produce greater improvements in a dysphagia evaluation than **sham stimulation.**	2	Suntrup-Kreuger et al., 2018; Kumar et al., 2011
1a	There is conflicting evidence about the effect of **ipsilesional anodal tDCS** to improve a dysphagia evaluation when compared to **a sham stimulation.**	2	Shigematsu et al., 2013; Yang et al., 2012

RESPIRATORY INFECTIONS			
LoE	**Conclusion Statement**	**RCTs**	**References**
2	**Contralesional anodal tDCS** may not have a difference in efficacy compared to **sham stimulation** for improving respiratory infections.	1	Suntrup-Kreuger et al., 2018

Key Points

Contralesional anodal tDCS may be beneficial for improving dysphagia evaluations, but not respiratory infections.

Repetitive Transcranial Magnetic Stimulation (rTMS)

Adapted from: https://www.technologynetworks.com/neuroscience/news/rtms-study-claims-to-improve-working-memory-319448

Another form of non-invasive brain stimulation comes in the form of magnetic stimulation over the affected area. Repetitive transcranial magnetic stimulation (rTMS) uses magnetic fields to evoke electrical/excitable changes in the area being stimulated. In stroke, rTMS has been evaluated in the field of motor function; however, few studies have looked at its usefulness at improving dysphagia outcomes (Liao et al., 2017).

Six RCTs were found evaluating rTMS for dysphagia rehabilitation. Two RCTs compared high frequency rTMS in ipsilesional cortex to sham stimulation (Cheng et al., 2017; Khedr et al., 2009). One RCT compared high frequency rTMS in contralesional cortex to sham stimulation (Park et al., 2013). One RCT compared bilateral high frequency rTMS to unilateral high frequency rTMS (Park et al., 2017). One RCT compared high frequency rTMS to low frequency rTMS (Du et al., 2016). One RCT compared high frequency vagus nerve stimulation to sham stimulation (Lin et al., 2017).

The methodological details and results of all six RCTs are presented in in **Table 23.**

Table 23. RCTs examining rTMS for dysphagia

Authors (Year) Study Design (PEDro Score) Sample Size$_{start}$ Sample Size$_{end}$ Time post stroke category	Interventions Duration: Session length, frequency per week for total number of weeks	Outcome Measures Result (direction of effect)
High frequency rTMS vs sham stimulation		
Cheng et al. (2017) RCT (3) N_{Start}=22 N_{End}=14 TPS=Chronic	E: High frequency rTMS (5Hz) (ipsilesional) C: Sham rTMS Duration: 15min 5x/wk for 2wk	• Videofluroscopic swallowing scores (-) • Swallowing Activity and Participation Profile (-) • Maximum tongue strength (-)
Khedr et al. (2009) RCT (6) N_{start}=26 N_{end}=22 TPS=Acute	E: Repetitive transcranial magnetic stimulation (3Hz) (ipsilesional) C: Sham stimulation Duration: 10min/d, 5d/wk for 1wk Statistical Analysis: ANOVA	• Dysphagic Outcome and Severity Scale: (+exp) • Barthel Index (+exp)
High frequency rTMS in contralesional cortex vs sham stimulation		
Park et al. (2013) RCT (8) N_{Start}=18 N_{End}=18 TPS=Acute	E: Repetitive transcranial magnetic stimulation (5Hz) (contralesional) C: Sham stimulation Duration: 10min/d, 5d/wk for 2wk Statistical Analysis: Mann-Whitney U Test	• Penetration-Aspiration scale: (-) • Videofluoroscopic dysphagia scale: (-)
High frequency bilateral rTMS vs high frequency rTMS		
Park et al. (2017) RCT (4) N_{Start}=35 N_{End}=33 TPS=Not Reported	E1: High frequency rTMS (10Hz) (500 pulses) bilaterally to both cortices E2: High frequency rTMS (10Hz) (500 pulses) to ipsilesional primary motor cortices C: Sham rTMS Duration: 5x/wk for 2wk	E1 vs E2/C • Clinical Dysphagia Scale (+exp1) • Dysphagia Outcome and Severity Scale (+exp1) • Penetration Aspiration Scale (+exp1) • Videofluroscopic Dysphagia Scale (+exp1)
High frequency rTMS vs low frequency rTMS vs sham		
Du et al. (2016) RCT (9) N_{Start}=40 N_{End}=38 TPS=Acute	E1: High Frequency (3Hz) rTMS (ipsilesional) E2: Low Frequency (1Hz) rTMS (contralesional) C: Sham Stimulation Duration: 30min/d, 5d/wk for 1wk Statistical Analysis: ANOVA	E1 vs C • Water Swallow Test (+exp1) • Degree of Dysphagia (+exp1) E2 vs C • Water Swallow Test (-) • Degree of Dysphagia (-) E1 vs E2 • Water Swallow Test (-) • Degree of Dysphagia (-)
High frequency rTMS for vagus nerve modulation vs sham stimulation		
Lin et al. (2017) RCT (6) N_{Start}=30 N_{End}=28 TPS=Chronic	E: High frequency rTMS (5Hz) (vagus nerve modulation) C: Sham rTMS Duration: 10min, 5x/wk for 2wk	• Penetration-Aspiration scale (+exp) • Australian Therapy Outcome Measures-Swallowing scale (+exp)

Abbreviations and table notes: C=control group; D=days; E=experimental group; H=hours; Min=minutes; RCT=randomized controlled trial; TPS=time post stroke category (Acute: less than 30 days, Subacute: more than 1 month but less than 6 months, Chronic: over 6 months); Wk=weeks.
+exp indicates a statistically significant between groups difference at α=0.05 in favour of the experimental group
+exp$_2$ indicates a statistically significant between groups difference at α=0.05 in favour of the second experimental group
+con indicates a statistically significant between groups difference at α=0.05 in favour of the control group
- indicates no statistically significant between groups differences at α=0.05

Conclusions about rTMS

PHARYNGEAL PHASE			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**High frequency rTMS in contralesional cortex** may not have a difference in efficacy compared to **a sham stimulation** for improving the pharyngeal phase.	1	Park et al., 2013
2	**Bilateral high frequency rTMS** may produce greater improvements in the pharyngeal phase than **unilateral high frequency rTMS.**	1	Park et al., 2017
1b	**Vagus nerve high frequency rTMS** may produce greater improvements in the pharyngeal phase than **a sham stimulation.**	1	Lin et al., 2017

ORAL PHASE			
LoE	**Conclusion Statement**	**RCTs**	**References**
2	**High frequency rTMS** may not have a difference in efficacy compared to **a sham stimulation** for improving the oral phase.	1	Cheng et al., 2017

DYSPHAGIA EVALUATIONS			
LoE	**Conclusion Statement**	**RCTs**	**References**
1a	There is conflicting evidence about the effect of **high frequency rTMS** to improve a dysphagia evaluation when compared to **a sham stimulation.**	2	Chen et al., 2017; Du et al., 2016; Khedr et al., 2009
1b	**High frequency rTMS in contralesional cortex** may not have a difference in efficacy compared to **a sham stimulation** for improving a dysphagia evaluation.	1	Park et al., 2013
2	**Bilateral high frequency rTMS** may produce greater improvements in a dysphagia evaluation than **unilateral high frequency rTMS.**	1	Park et al., 2017
1b	**Low frequency rTMS** may not have a difference in efficacy compared to **s sham stimulation** for improving a dysphagia evaluation.	1	Du et al., 2016
1b	**High frequency rTMS** may not have a difference in efficacy compared to **low frequency rTMS** for improving a dysphagia evaluation.	1	Du et al., 2016
1b	**Vagus nerve high frequency rTMS** may produce greater improvements in a dysphagia evaluation than **a sham stimulation.**	1	Lin et al., 2017

ACTIVITIES OF DAILY LIVING			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	There is conflicting evidence about the effect of **high frequency rTMS** to improve activities of daily living when compared to **a sham stimulation.**	2	Cheng et al., 2017; Khedr et al., 2009

Key Points

The literature is mixed concerning the efficacy of high frequency rTMS for dysphagia and activities of daily living.

Bilateral rTMS may lead to greater improvements in dysphagia than unilateral rTMS.

Functional Magnetic Neuromuscular Stimulation

Adapted from: https://www.iskramedical.eu/en/magneto-fms-therapy/tesla-stym

Functional magnetic stimulation works on the same principles as repetitive transcranial magnetic stimulation, but where rTMS applies its field directly to the cortex, functional magnetic stimulation applies the field to nerve tissue, stimulating the efferent connections and inducing muscle contractions (Polkey et al., 1999). The magnetic field stimulation could achieve the same result as neuromuscular electrical stimulation, but it is not associated with the pain that is often reported while undergoing electrical stimulation (Ruohonen, Ravazzani & Grandori, 1998).

One RCT was found evaluating functional magnetic stimulation for dysphagia rehabilitation. It compared functional magnetic stimulation to sham stimulation (Momosaki et al., 2014).

The methodological details and results of the single RCT are presented in in **Table 24.**

Table 24. RCTs examining functional magnetic stimulation for dysphagia

Authors (Year) Study Design (PEDro Score) Sample Size$_{start}$ Sample Size$_{end}$ Time post stroke category	Interventions Duration: Session length, frequency per week for total number of weeks	Outcome Measures Result (direction of effect)
Momosaki et al. (2014) RCT (6) N_{Start}=20 N_{End}=20 TPS=Chronic	E: Functional magnetic neuromuscular stimulation (30hz) C: Sham stimulation Duration: 10min/d, 5d/wk for 2wk Statistical Analysis: Mann-Whitney U Test	• Interswallow interval (-) • Swallow Speed: (+exp) • Swallow Capacity: (+exp)

Abbreviations and table notes: C=control group; D=days; E=experimental group; H=hours; Min=minutes; RCT=randomized controlled trial; TPS=time post stroke category (Acute: less than 30 days, Subacute: more than 1 month but less than 6 months, Chronic: over 6 months); Wk=weeks.

+exp indicates a statistically significant between groups difference at α=0.05 in favour of the experimental group
+exp$_2$ indicates a statistically significant between groups difference at α=0.05 in favour of the second experimental group
+con indicates a statistically significant between groups difference at α=0.05 in favour of the control group
- indicates no statistically significant between groups differences at α=0.05

Conclusions about functional magnetic neuromuscular stimulation

PHARYNGEAL PHASE			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Functional magnetic neuromuscular stimulation** may not have a difference in efficacy compared to **sham stimulation** for improving the pharyngeal phase.	1	Momosaki et al., 2014

DYSPHAGIA EVALUATIONS			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Functional magnetic neuromuscular stimulation** may produce greater improvements in a dysphagia evaluation than a **sham stimulation.**	1	Momosaki et al., 2014

Key Points

Functional magnetic neuromuscular stimulation may improve dysphagia evaluations but does not appear to improve the pharyngeal phase.

Pharmacotherapy

Adapted from: https://www.fau.eu/2013/09/26/news/research/six-million-euros-for-better-pharmacotherapy-for-children-and-adolescents/

In addition to the variety of physical therapies, behavioural strategies and external stimulation methods used to treat dysphagia, some research is asking whether or not there are any pharmacological agents which can help ameliorate the condition and/or provide added benefit to traditional therapy. Because it is a motor disorder levodopa and carbidopa are often used as a treatment (Chen et al., 2017). Recently, other drugs generally used to treat other conditions are now being examined for the treatment of dysphagia based on different proposed protective or therapeutic effects.

Two RCTs were found evaluating pharmacotherapy for dysphagia rehabilitation. One RCT compared levetiracetam to levodopa plus carbidopa to a placebo (Chen et al., 2017). One RCT compared aspirin with cilostazol to aspirin alone (Abe et al., 2013).

The methodological details and results of all two RCTs are presented in in **Table 25.**

Table 25. RCTs examining pharmacotherapy for dysphagia

Authors (Year) Study Design (PEDro Score) Sample Size$_{start}$ Sample Size$_{end}$ Time post stroke category	Interventions Duration: Session length, frequency per week for total number of weeks	Outcome Measures Result (direction of effect)
Levetiracetam vs Levodopa vs Placebo		
Chen et al. (2017) RCT (4) N_{Start}=638 N_{End}=613 TPS=Acute	E1: Levetiracetam (500mg) E2: Levodopa (250mg) + Carbidopa (25mg) C: Placebo Duration: 2x/d for 8wk	E1 vs E2 • Bolus speed (-) • Mastication speed (-) • Jaw excursion (-) • Bolus Area (-) E1 vs C • Bolus speed (+exp1) • Mastication speed (+exp1) • Jaw excursion (+exp1) • Bolus Area (+exp1) E2 vs C • Bolus speed (+exp2) • Mastication speed (+exp2) • Jaw excursion (-) • Bolus Area (+exp2)
Aspirin + cilostazol vs aspirin alone		
Abe et al. (2013) RCT (4) N_{Start}=21 N_{End}=20 TPS=Acute	E: Aspirin + cilostazol C: Aspirin Duration: 100mg/d of aspirin + 100mg/d of cilostazol, 7d/wk for 24wk Statistical Analysis: Mann-Whitney U Test	• Latent time of swallowing reflex (-)

Abbreviations and table notes: C=control group; D=days; E=experimental group; H=hours; Min=minutes; RCT=randomized controlled trial; TPS=time post stroke category (Acute: less than 30 days, Subacute: more than 1 month but less than 6 months, Chronic: over 6 months); Wk=weeks.
+exp indicates a statistically significant between groups difference at α=0.05 in favour of the experimental group
+exp$_2$ indicates a statistically significant between groups difference at α=0.05 in favour of the second experimental group
+con indicates a statistically significant between groups difference at α=0.05 in favour of the control group
- indicates no statistically significant between groups differences at α=0.05

Conclusions about pharmacotherapy

PHARYNGEAL PHASE			
LoE	**Conclusion Statement**	**RCTs**	**References**
2	**Aspirin with cilostazol** may not have a difference in efficacy compared to **aspirin alone** for improving the pharyngeal phase.	1	Abe et al., 2013

ORAL PHASE			
LoE	**Conclusion Statement**	**RCTs**	**References**
2	**Levetiracetam** may produce greater improvements in a dysphagia evaluation **a placebo.**	1	Chen et al., 2017
2	There is conflicting evidence about the effect of **levodopa and carbidopa** to improve the oral phase when compared to **a placebo.**	1	Chen et al., 2017
2	**Levetiracetam** may not have a difference in efficacy compared to **levodopa and carbidopa** for improving the oral phase.	1	Chen et al. 2017

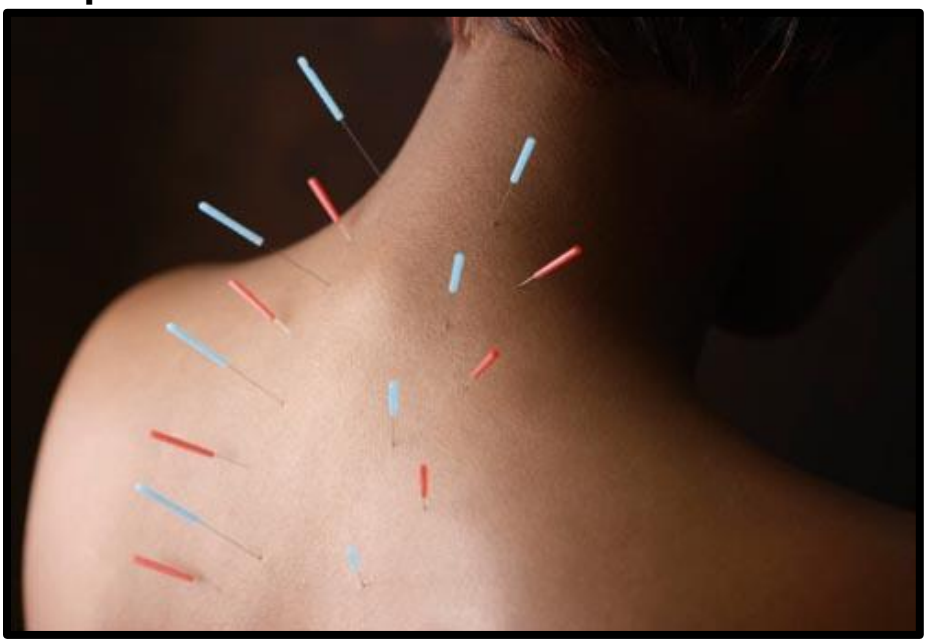
DYSPHAGIA EVALUATIONS			
LoE	**Conclusion Statement**	**RCTs**	**References**
2	**Levetiracetam** may produce greater improvements in a dysphagia evaluation **a placebo.**	1	Chen et al., 2017
2	**Levodopa and carbidopa** may produce greater improvements in a dysphagia evaluation **a placebo.**	1	Chen et al., 2017
2	**Levetiracetam** may not have a difference in efficacy compared to **levodopa and carbidopa** for improving a dysphagia evaluation.	1	Chen et al. 2017

Key Points

Levetiracetam may be beneficial for improving dysphagia evaluations and the oral phase.

The may not be a difference in dysphagia evaluation outcomes between levetiracetam and levodopa with carbidopa.

Acupuncture



Adapted from: https://www.webmd.com/pain-management/ss/slideshow-acupuncture-overview

The use of acupuncture has recently gained attention as an adjunct to stroke rehabilitation in Western countries even though acupuncture has been a primary treatment method in China for about 2000 years (Baldry, 2005). In China, acupuncture is an acceptable, time-efficient, simple, safe and economical form of treatment used to ameliorate motor, sensation, verbal communication and further neurological functions in post-stroke patients," (Wu et al., 2002). According to Rabinstein and Shulman (2003), "Acupuncture is a therapy that involves stimulation of defined anatomic locations on the skin by a variety of techniques, the most common being stimulation with metallic needles that are manipulated either manually or that serve as electrodes conducting electrical currents". There is a range of possible acupuncture mechanisms that may contribute to the health benefits experienced by stroke patients (Park et al. 2006). For example, acupuncture may stimulate the release of neurotransmitters (Han & Terenius, 1982) and have an effect on the deep structure of the brain (Wu et al. 2002). Lo et al. (2005) established acupuncture, when applied for at least 10 minutes, led to long-lasting changes in cortical excitability and plasticity even after the needle stimulus was removed. With respect to stroke rehabilitation, the benefit of acupuncture has been evaluated most frequently for pain relief and recovery from hemiparesis.

One RCT was found evaluating acupuncture for dysphagia rehabilitation. It compared acupuncture with swallowing therapy to standard swallowing therapy alone (Xia et al., 2016).

The methodological details and results of the single RCT are presented in in **Table 26.**

Table 26. RCTs examining acupuncture for dysphagia

Authors (Year) Study Design (PEDro Score) Sample Size$_{start}$ Sample Size$_{end}$ Time post stroke category	Interventions Duration: Session length, frequency per week for total number of weeks	Outcome Measures Result (direction of effect)
Xia et al. (2016) RCT (6) N_{Start}=124 N_{End}=120 TPS=Acute	E: Acupuncture + Standard Swallowing Therapy C: Standard Swallowing Therapy Duration: 30min/d, 6d/wk for 4wk	• Standardized swallowing assessment (+con) • Dysphagia Outcome Severity Scale (+exp) • Modified Barthel Index (+exp)

Abbreviations and table notes: C=control group; D=days; E=experimental group; H=hours; Min=minutes; RCT=randomized controlled trial; TPS=time post stroke category (Acute: less than 30 days, Subacute: more than 1 month but less than 6 months, Chronic: over 6 months); Wk=weeks.
+exp indicates a statistically significant between groups difference at α=0.05 in favour of the experimental group
+exp$_2$ indicates a statistically significant between groups difference at α=0.05 in favour of the second experimental group
+con indicates a statistically significant between groups difference at α=0.05 in favour of the control group
- indicates no statistically significant between groups differences at α=0.05

Conclusions about acupuncture

DYSPHAGIA EVALUATIONS			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	There is conflicting evidence about the effect of **acupuncture with swallowing therapy** to improve a dysphagia evaluation when compared to **conventional care.**	1	Xia et al., 2016

ACTIVITIES OF DAILY LIVING			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Acupuncture with swallowing therapy** may produce greater improvements in activities of daily living than **conventional care.**	1	Xia et al., 2016

Key Points

There is conflicting evidence concerning acupunctures ability to improve dysphagia evaluation outcomes.

References

Abe, A., Nishiyama, Y., Hagiwara, H., Okubo, S., Ueda, M., Katsura, K., & Katayama, Y. (2013). Administration of cilostazol, an antiplatelet, to patients with acute-stage cerebral infarction and its effects on plasma substance p level and latent time of swallowing reflex. *Journal of Nippon Medical School, 80*(1), 50-56. doi:http://dx.doi.org/10.1272/jnms.80.50

Alsumrain, M., Melillo, N., DeBari, V. A., Kirmani, J., Moussavi, M., Doraiswamy, V., . . . Miller, R. (2013). Predictors and outcomes of pneumonia in patients with spontaneous intracerebral hemorrhage. *Journal of intensive care medicine, 28*(2), 118-123.

Altman, K. W. (2012). Oropharyngeal dysphagia pathophysiology, complications and science-based interventions. *Nestle.Nutr Inst.Workshop Ser., 72*, 119-126. doi:000340000 [pii];10.1159/000340000 [doi]

Alves, L. M. T., Cassiani, R. D. A., Santos, C. M. D., & Dantas, R. O. (2007). Gender effect on the clinical measurement of swallowing. *Arquivos de gastroenterologia*, *44*(3), 227-229.

Anderson, M. R., O'Connor, M., Mayer, P., O'Mahony, D., Woodward, J., & Kane, K. (2004). The nasal loop provides an alternative to percutaneous endoscopic gastrostomy in high-risk dysphagic stroke patients. *Clin Nutr., 23*(4), 501-506. doi:10.1016/j.clnu.2003.09.008 [doi];S0261561403002048 [pii]

Arai, T., Sekizawa, K., Yoshimi, N., Toshima, S., & Fujiwara, H. (2003). Cabergoline and silent aspiration in elderly patients with stroke. *J.Am.Geriatr.Soc., 51*(12), 1815-1816. doi:51572_2 [pii]

Arai, T., Yasuda, Y., Takaya, T., Toshima, S., Kashiki, Y., Yoshimi, N., & Fujiwara, H. (1998). ACE inhibitors and symptomless dysphagia. *Lancet, 352*(9122), 115-116. doi:S0140-6736(98)85021-6 [pii];10.1016/S0140-6736(98)85021-6 [doi]

Arms, R. A., Dines, D. E., & Tinstman, T. C. (1974). Aspiration pneumonia. *Chest, 65*(2), 136-139.

Armstrong, R., White, S., Streak, J., & Tivey, D. (2013). The effect of nasal introduction of anaesthetic in adults undergoing fibreoptic endoscopic evaluation of swallowing (FEES): A systematic review protocol. *JBI Database of Systematic Reviews and Implementation Reports, 11*(6), 259-274. doi:http://dx.doi.org/10.11124/jbisrir-2013-1071

Aviv, J. E., Kaplan, S. T., Thomson, J. E., Spitzer, J., Diamond, B., & Close, L. G. (2000). The safety of flexible endoscopic evaluation of swallowing with sensory testing (FEESST): an analysis of 500 consecutive evaluations. *Dysphagia, 15*(1), 39-44. doi:DYS535 [pii]

Bach, D. B., Pouget, S., Belle, K., Kilfoil, M., Alfieri, M., McEvoy, J., & Jackson, G. (1989). An integrated team approach to the management of patients with oropharyngeal dysphagia. *J.Allied Health, 18*(5), 459-468.

Bakhtiyari, J., Salmani, M., Noruzi, R., Sarraf, P., Barzegar, E., & Mirmohammadkhani, M. (2018). Translation, cross-cultural adaptation, validation and reliability of the northwestern dysphagia patient check sheet (NDPCS) in Iran. *Iranian journal of otorhinolaryngology*, *30*(97), 97.

Bakhtiyari, J., Sarraf, P., Nakhostin-Ansari, N., Tafakhori, A., Logemann, J., Faghihzadeh, S., & Harirchian, M. H. (2015). Effects of early intervention of swallowing therapy on recovery from dysphagia following stroke. *Iranian Journal of Neurology, 14*(3), 119-124.

Baldry, P. (2005). The Integration of Acupuncture within Medicine in the UK–the British Medical Acupuncture Society—s 25Th Anniversary. *Acupuncture in Medicine, 23*(1), 2-12.

Barer, D. H. (1989). The natural history and functional consequences of dysphagia after hemispheric stroke. *J.Neurol.Neurosurg.Psychiatry, 52*(2), 236-241.

Barquist, E., Brown, M., Cohn, S., Lundy, D., & Jackowski, J. (2001). Postextubation fiberoptic endoscopic evaluation of swallowing after prolonged endotracheal intubation: a randomized, prospective trial. *Crit Care Med, 29*(9), 1710-1713.

Bartnikas, T. B. (2012). Known and potential roles of transferrin in iron biology. *Biometals*, *25*(4), 677-686.

Bath, P. M., Scutt, P., Love, J., Clave, P., Cohen, D., Dziewas, R., . . . Hamdy, S. (2016). Pharyngeal Electrical Stimulation for Treatment of Dysphagia in Subacute Stroke: A Randomized Controlled Trial. *Stroke, 47*(6), 1562-1570. doi:10.1161/strokeaha.115.012455

Bax, L., McFarlane, M., Green, E., & Miles, A. (2014). Speech-language pathologist-led fiberoptic endoscopic evaluation of swallowing: functional outcomes for patients after stroke. *Journal of Stroke & Cerebrovascular Diseases, 23*(3), E195-E200. doi:http://dx.doi.org/10.1016/j.jstrokecerebrovasdis.2013.09.031

Beavan, J., Conroy, S. P., Harwood, R., Gladman, J. R., Leonardi-Bee, J., Sach, T., . . . Gaynor, C. (2010). Does looped nasogastric tube feeding improve nutritional delivery for patients with dysphagia after acute stroke? A randomised controlled trial. *Age Ageing, 39*(5), 624-630. doi:afq088 [pii];10.1093/ageing/afq088 [doi]

Beck, F. K., & Rosenthal, T. C. (2002). Prealbumin: a marker for nutritional evaluation. *American family physician*, *65*(8).

Bell, S. (1996). Use of Passy-Muir tracheostomy speaking valve in mechanically ventilated neurological patients. *Critical care nurse, 16*(1), 63-68.

Bergstrom, L., Svensson, P., & Hartelius, L. (2014). Cervical auscultation as an adjunct to the clinical swallow examination: A comparison with fibre-optic endoscopic evaluation of swallowing. *International Journal of Speech-Language Pathology, 16*(5), 517-528. doi:http://dx.doi.org/10.3109/17549507.2013.855259

Boesch, R. P., & Deboer, E. M. (2019). Aspiration. In *Kendig's Disorders of the Respiratory Tract in Children* (pp. 1097-1105). Content Repository Only!.

Bolhuis, D. P., Lakemond, C. M., de Wijk, R. A., Luning, P. A., & de Graaf, C. (2014). Both a higher number of sips and a longer oral transit time reduce ad libitum intake. *Food quality and preference*, *32*, 234-240.

Bounds, J. V., Wiebers, D. O., Whisnant, J. P., & Okazaki, H. (1981). Mechanisms and timing of deaths from cerebral infarction. *Stroke, 12*(4), 474-477.

Broadley, S., Croser, D., Cottrell, J., Creevy, M., Teo, E., Yiu, D., . . . Thompson, P. D. (2003). Predictors of prolonged dysphagia following acute stroke. *J.Clin Neurosci., 10*(3), 300-305. doi:S0967586803000225 [pii]

Brown, M., & Glassenberg, M. (1973). Mortality factors in patients with acute stroke. *JAMA, 224*(11), 1493-1495.

Búa, B. A., Olsson, R., Westin, U., Rydell, R., & Ekberg, O. (2015). Treatment of cricopharyngeal dysfunction: a comparative pilot study. *BMC research notes*, *8*(1), 301.

Bulow, M., Speyer, R., Baijens, L., Woisard, V., & Ekberg, O. (2008). Neuromuscular electrical stimulation (NMES) in stroke patients with oral and pharyngeal dysfunction. *Dysphagia, 23*(3), 302-309. doi:10.1007/s00455-007-9145-9 [doi]

Byeon, H., & Koh, H. W. (2016). Comparison of treatment effect of neuromuscular electrical stimulation and thermal-tactile stimulation on patients with sub-acute dysphagia caused by stroke. *Journal of physical therapy science, 28*(6), 1809-1812. doi:10.1589/jpts.28.1809

Carnaby, G., Hankey, G. J., & Pizzi, J. (2006). Behavioural intervention for dysphagia in acute stroke: a randomised controlled trial. *Lancet Neurol., 5*(1), 31-37. doi:S1474-4422(05)70252-0 [pii];10.1016/S1474-4422(05)70252-0 [doi]

Cascieri, M., Bull, H., Mumford, R., Patchett, A., Thornberry, N., & Liang, T. (1984). Carboxyl-terminal tripeptidyl hydrolysis of substance P by purified rabbit lung angiotensin-converting enzyme and the potentiation of substance P activity in vivo by captopril and MK-422. *Molecular pharmacology, 25*(2), 287-293.

Chastre, J., & Fagon, J.-Y. (2002). Ventilator-associated pneumonia. *American journal of respiratory and critical care medicine, 165*(7), 867-903.
Chen, D., Xing, H., Jiang, Q., Xiang, Y., Hu, W., & Guo, H. (2017). Role of Levetiracetam in the Rehabilitation of Dysphagia due to Stroke. *International Journal of Pharmacology, 13*(6), 603-611.
Chen, M. Y., Ott, D. J., Peele, V. N., & Gelfand, D. W. (1990). Oropharynx in patients with cerebrovascular disease: evaluation with videofluoroscopy. *Radiology, 176*(3), 641-643.
Cheng, I. K. Y., Chan, K. M. K., Wong, C. S., Li, L. S. W., Chiu, K. M. Y., Cheung, R. T. F., & Yiu, E. M. L. (2017). Neuronavigated high-frequency repetitive transcranial magnetic stimulation for chronic post-stroke dysphagia: A randomized controlled study. *J Rehabil Med, 49*(6), 475-481. doi:10.2340/16501977-2235
Choi, J.-B., Shim, S.-H., Yang, J.-E., Kim, H.-D., Lee, D.-H., & Park, J.-S. (2017). Effects of Shaker exercise in stroke survivors with oropharyngeal dysphagia. *NeuroRehabilitation, 41*(4), 753-757.
Chojin, Y., Kato, T., Rikihisa, M., Omori, M., Noguchi, S., Akata, K., ... & Mukae, H. (2017). Evaluation of the mann assessment of swallowing ability in elderly patients with pneumonia. *Aging and disease*, *8*(4), 420.
Clavé, P., Arreola, V., Romea, M., Medina, L., Palomera, E., & Serra-Prat, M. (2008). Accuracy of the volume-viscosity swallow test for clinical screening of oropharyngeal dysphagia and aspiration. *Clinical Nutrition*, *27*(6), 806-815.
Clayton, B. (2012). Stroke, dysphagia and oral care: what is best practice? *Alberta RN/Alberta Association of Registered Nurses, 68*(1), 26.
Clayton, J., Jack, C. I., Ryall, C., Tran, J., Hilal, E., & Gosney, M. (2006). Tracheal pH monitoring and aspiration in acute stroke. *Age Ageing, 35*(1), 47-53. doi:35/1/47 [pii];10.1093/ageing/afj007 [doi]
Cohen, D. L., Roffe, C., Beavan, J., Blackett, B., Fairfield, C. A., Hamdy, S., . . . Randall, M. (2016). Post-stroke dysphagia: A review and design considerations for future trials. *International Journal of Stroke, 11*(4), 399-411.
Cohen, E., Mier, A., Heywood, P., Murphy, K., Boultbee, J., & Guz, A. (1994). Diaphragmatic movement in hemiplegic patients measured by ultrasonography. *Thorax, 49*(9), 890-895.
Coia, L. R., Soffen, E. M., Schultheiss, T. E., Martin, E. E., & Hanks, G. E. (1993). Swallowing function in patients with esophageal cancer treated with concurrent radiation and chemotherapy. *Cancer*, *71*(2), 281-286.
Collins, M. J., & Bakheit, A. M. (1997). Does pulse oximetry reliably detect aspiration in dysphagic stroke patients? *Stroke, 28*(9), 1773-1775.
Crary, M. A., Mann, G. D. C., & Groher, M. E. (2005). Initial psychometric assessment of a intake scale for dysphagia in stroke patients. *Archives of physical medicine and rehabilitation*, *86*(8), 1516-1520.
Daniels, S. K. (2000). *Optimal patterns of care for dysphagic stroke patients.* Paper presented at the Seminars in speech and language.
Daniels, S. K., Anderson, J. A., & Willson, P. C. (2012). Valid items for screening dysphagia risk in patients with stroke: a systematic review. *Stroke., 43*(3), 892-897.
Daniels, S. K., Brailey, K., Priestly, D. H., Herrington, L. R., Weisberg, L. A., & Foundas, A. L. (1998). Aspiration in patients with acute stroke. *Arch Phys Med Rehabil., 79*(1), 14-19.
de Lama Lazzara, G., Lazarus, C., & Logemann, J. A. (1986). Impact of thermal stimulation on the triggering of the swallowing reflex. *Dysphagia, 1*(2), 73-77.
Dennis, M. S., Lewis, S. C., & Warlow, C. (2005a). Effect of timing and method of enteral tube feeding for dysphagic stroke patients (FOOD): a multicentre randomised controlled trial. *Lancet, 365*(9461), 764-772. doi:S0140673605179835 [pii];10.1016/S0140-6736(05)17983-5 [doi]

DePippo, K. L., Holas, M. A., & Reding, M. J. (1994). The Burke dysphagia screening test: validation of its use in patients with stroke. *Arch.Phys.Med.Rehabil., 75*(12), 1284-1286. doi:0003-9993(94)90274-7 [pii]

DePippo, K. L., Holas, M. A., Reding, M. J., Mandel, F. S., & Lesser, M. L. (1994). Dysphagia therapy following stroke: a controlled trial. *Neurology, 44*(9), 1655-1660.

Dettelbach, M. A., Gross, R. D., Mahlmann, J., & Eibling, D. E. (1995). Effect of the Passy-Muir valve on aspiration in patients with tracheostomy. *Head & neck, 17*(4), 297-302.

Deurenberg, P., Pieters, J. J., & Hautvast, J. G. (1990). The assessment of the body fat percentage by skinfold thickness measurements in childhood and young adolescence. *British Journal of Nutrition*, *63*(2), 293-303.

Ding, R., & Logemann, J. A. (2000). Pneumonia in stroke patients: a retrospective study. *Dysphagia, 15*(2), 51-57.

Diniz, P. B., Vanin, G., Xavier, R., & Parente, M. A. (2009). Reduced incidence of aspiration with spoon-thick consistency in stroke patients. *Nutr.Clin Pract., 24*(3), 414-418. doi:24/3/414 [pii];10.1177/0884533608329440 [doi]

Du, J., Yang, F., Liu, L., Hu, J., Cai, B., Liu, W., . . . Liu, X. (2016). Repetitive transcranial magnetic stimulation for rehabilitation of poststroke dysphagia: A randomized, double-blind clinical trial. *Clin Neurophysiol, 127*(3), 1907-1913. doi:10.1016/j.clinph.2015.11.045

Dziewas, R., Warnecke, T., Hamacher, C., Oelenberg, S., Teismann, I., Kraemer, C., . . . Schaebitz, W. R. (2008). Do nasogastric tubes worsen dysphagia in patients with acute stroke? *BMC.Neurol., 8*, 28. doi:1471-2377-8-28 [pii];10.1186/1471-2377-8-28 [doi]

El-Tamawy, M. S., Darwish, M. H., El-Azizi, H. S., Abdelalim, A. M., & Taha, S. I. (2015). The influence of physical therapy on oropharyngeal dysphagia in acute stroke patients. *Egyptian Journal of Neurology, Psychiatry and Neurosurgery, 52*(3), 201-205. doi:10.4103/1110-1083.162046

Elpern, E. H., Okonek, M. B., Bacon, M., Gerstung, C., & Skrzynski, M. (2000). Effect of the Passy-Muir tracheostomy speaking valve on pulmonary aspiration in adults. *Heart & lung, 29*(4), 287-293.

Eom, M. J., Chang, M. Y., Oh, D. H., Kim, H. D., Han, N. M., & Park, J. S. (2017). Effects of resistance expiratory muscle strength training in elderly patients with dysphagic stroke. *NeuroRehabilitation, 41*(4), 747-752. doi:10.3233/nre-172192

Ertekin, C., Aydoğdu, I., & Yüceyar, N. (1996). Piecemeal deglutition and dysphagia limit in normal subjects and in patients with swallowing disorders. *Journal of Neurology, Neurosurgery & Psychiatry*, *61*(5), 491-496.

Ertekin, C., Aydogdu, I., Yüceyar, N., Kiylioglu, N., Tarlaci, S., & Uludag, B. (2000). Pathophysiological mechanisms of oropharyngeal dysphagia in amyotrophic lateral sclerosis. *Brain*, *123*(1), 125-140.

Falsetti, P., Acciai, C., Palilla, R., Bosi, M., Carpinteri, F., Zingarelli, A., . . . Lenzi, L. (2009). Oropharyngeal dysphagia after stroke: incidence, diagnosis, and clinical predictors in patients admitted to a neurorehabilitation unit. *Journal of Stroke and Cerebrovascular Diseases, 18*(5), 329-335.

Fields, L. B. (2008). Oral care intervention to reduce incidence of ventilator-associated pneumonia in the neurologic intensive care unit. *Journal of Neuroscience Nursing, 40*(5), 291-298.

Finegold, S. M. (1991). Aspiration pneumonia. *Review of Infectious Diseases, 13*(Supplement 9), S737-S742.

Finestone, H. M., Greene-Finestone, L. S., Wilson, E. S., & Teasell, R. W. (1995). Malnutrition in stroke patients on the rehabilitation service and at follow-up: prevalence and predictors. *Arch.Phys.Med.Rehabil., 76*(4), 310-316. doi:S0003-9993(95)80655-5 [pii]

Finlayson, O., Kapral, M., Hall, R., Asllani, E., Selchen, D., & Saposnik, G. (2011). Risk factors, inpatient care, and outcomes of pneumonia after ischemic stroke. *Neurology, 77*(14), 1338-1345. doi:10.1212/WNL.0b013e31823152b1

Flowers, H. L., Skoretz, S. A., Streiner, D. L., Silver, F. L., & Martino, R. (2011). MRI-based neuroanatomical predictors of dysphagia after acute ischemic stroke: a systematic review and meta-analysis. *Cerebrovascular diseases, 32*(1), 1-10.

Galovic, M., Leisi, N., Muller, M., Weber, J., Abela, E., Kagi, G., & Weder, B. (2013). Lesion Location Predicts Transient and Extended Risk of Aspiration After Supratentorial Ischemic Stroke. *Stroke*. doi:STROKEAHA.113.001690 [pii];10.1161/STROKEAHA.113.001690 [doi]

Garon, B. R., Engle, M., & Ormiston, C. (1997). A randomized control study to determine the effects of unlimited oral intake of water in patients with identified aspiration. *Neurorehabilitation and Neural Repair, 11*(3), 139-148.

Goda, T., Mahmoud, W., Abdeldayem, S. M., & Al Afifi, M. T. (2015). Post-stroke pneumonia. *Egyptian Journal of Neurology, Psychiatry and Neurosurgery, 52*(1), 51-54. doi:http://dx.doi.org/

Gordon, C., Hewer, R. L., & Wade, D. T. (1987). Dysphagia in acute stroke. *Br.Med.J.(Clin Res.Ed), 295*(6595), 411-414.

Gottlieb, D., Kipnis, M., Sister, E., Vardi, Y., & Brill, S. (1996). Validation of the 50 ml3 drinking test for evaluation of post-stroke dysphagia. *Disabil.Rehabil., 18*(10), 529-532.

Goulding, R., & Bakheit, A. M. (2000). Evaluation of the benefits of monitoring fluid thickness in the dietary management of dysphagic stroke patients. *Clin Rehabil., 14*(2), 119-124.

Groher, M. E. (1987). Bolus management and aspiration pneumonia in patients with pseudobulbar dysphagia. *Dysphagia, 1*(4), 215-216.

Guillen-Sola, A., Messagi Sartor, M., Bofill Soler, N., Duarte, E., Barrera, M. C., & Marco, E. (2017). Respiratory muscle strength training and neuromuscular electrical stimulation in subacute dysphagic stroke patients: a randomized controlled trial. *Clin Rehabil, 31*(6), 761-771. doi:10.1177/0269215516652446.

Gunduz, A., Turedi, S., Mentese, A., Altunayoglu, V., Turan, I., Karahan, S. C., ... & Akcan, B. (2008). Ischemia-modified albumin levels in cerebrovascular accidents. *The American journal of emergency medicine*, *26*(8), 874-878.

Hamlet, S. L., Muz, J., Patterson, R., & Jones, L. (1989). Pharyngeal transit time: assessment with videofluoroscopic and scintigraphic techniques. *Dysphagia, 4*(1), 4-7.

Han, J., & Terenius, L. (1982). Neurochemical basis of acupuncture analgesia. *Annual review of pharmacology and toxicology, 22*(1), 193-220.

Hannig, C., Wuttge-Hannig, A., Hormann, M., & Herrmann, I. F. (1989). [Cinematographic study of the pathologic mechanisms of aspiration pneumonia]. *RoFo: Fortschritte auf dem Gebiete der Rontgenstrahlen und der Nuklearmedizin, 150*(3), 260.

Hansen, T. S., & Jakobsen, D. (2010). A decision-algorithm defining the rehabilitation approach:'Facial oral tract therapy'®. Disability and rehabilitation, 32(17), 1447-1460.

Harms, H., Grittner, U., Dröge, H., & Meisel, A. (2013). Predicting post-stroke pneumonia: the PANTHERIS score. *Acta neurologica Scandinavica, 128*(3), 178-184.

Heart and Stroke Foundation of Ontario. (2002). Improving Recognition and Management of Dysphagia in Acute Stroke. In.

Hinchey, J. A., Shephard, T., Furie, K., Smith, D., Wang, D., & Tonn, S. (2005). Formal dysphagia screening protocols prevent pneumonia. *Stroke, 36*(9), 1972-1976. doi:01.STR.0000177529.86868.8d [pii];10.1161/01.STR.0000177529.86868.8d [doi]

Horiguchi, S., & Suzuki, Y. (2011). Screening tests in evaluating swallowing function. *JMAJ*, *54*(1), 31-4.

Holas, M. A., DePippo, K. L., & Reding, M. J. (1994). Aspiration and relative risk of medical complications following stroke. *Arch.Neurol., 51*(10), 1051-1053.

Hoppers, P., & Holm, S. E. (1999). The role of fiberoptic endoscopy in dysphagia rehabilitation. *The Journal of head trauma rehabilitation, 14*(5), 475-485.

Horner, J., & Massey, E. W. (1988). Silent aspiration following stroke. *Neurology, 38*(2), 317-319.

Horner, J., Massey, E. W., Riski, J. E., Lathrop, D. L., & Chase, K. N. (1988). Aspiration following stroke: clinical correlates and outcome. *Neurology, 38*(9), 1359-1362.

Hsiao, M. Y., Chang, Y. C., Chen, W. S., Chang, H. Y., & Wang, T. G. (2012). Application of ultrasonography in assessing oropharyngeal dysphagia in stroke patients. *Ultrasound Med Biol., 38*(9), 1522-1528. doi:S0301-5629(12)00254-2 [pii];10.1016/j.ultrasmedbio.2012.04.017 [doi]

Huang, K. L., Liu, T. Y., Huang, Y. C., Leong, C. P., Lin, W. C., & Pong, Y. P. (2014). Functional outcome in acute stroke patients with oropharyngeal dysphagia after swallowing therapy. *Journal of Stroke & Cerebrovascular Diseases, 23*(10), 2547-2553. doi:http://dx.doi.org/10.1016/j.jstrokecerebrovasdis.2014.05.031

Huang, Y. H., Chang, S. C., Kao, P. F., Chiang, T. H., Chen, S. L., Lee, M. S., & Wu, M. C. (2013). The value of pharyngeal scintigraphy in predicting videofluoroscopic findings. *American journal of physical medicine & rehabilitation, 92*(12), 1075-1083. doi:http://dx.doi.org/10.1097/PHM.0b013e31829e77e3

Hull, M. A., Rawlings, J., Murray, F. E., Field, J., McIntyre, A. S., Mahida, Y. R., . . . Allison, S. P. (1993). Audit of outcome of long-term enteral nutrition by percutaneous endoscopic gastrostomy. *Lancet, 341*(8849), 869-872. doi:0140-6736(93)93072-9 [pii]

Humphreys, B., Mathog, R., Rosen, R., Miller, P., Muz, J., & Nelson, R. (1987). Videofluoroscopic and scintigraphic analysis of dysphagia in the head and neck cancer patient. *The Laryngoscope, 97*(1), 25-32.

Huxley, E. J., Viroslav, J., Gray, W. R., & Pierce, A. K. (1978). Pharyngeal aspiration in normal adults and patients with depressed consciousness. *The American journal of medicine, 64*(4), 564-568.

Israili, Z. H., & Hall, W. D. (1992). Cough and angioneurotic edema associated with angiotensin-converting enzyme inhibitor therapy. *Ann Intern Med, 117*(3), 234-242.

Jadcherla, S. R., Gupta, A., Stoner, E., Fernandez, S., & Shaker, R. (2007). Pharyngeal swallowing: defining pharyngeal and upper esophageal sphincter relationships in human neonates. *The Journal of pediatrics*, *151*(6), 597-603.

Jaradeh, S. (2006). Muscle disorders affecting oral and pharyngeal swallowing. *GI Motility online*.

Jayasekeran, V., Singh, S., Tyrrell, P., Michou, E., Jefferson, S., Mistry, S., . . . Hamdy, S. (2010). Adjunctive functional pharyngeal electrical stimulation reverses swallowing disability after brain lesions. *Gastroenterology, 138*(5), 1737-1746. doi:S0016-5085(10)00161-7 [pii];10.1053/j.gastro.2010.01.052 [doi]

Jean, A. (2001). Brain stem control of swallowing: neuronal network and cellular mechanisms. *Physiol Rev., 81*(2), 929-969.

John, J. S., & Berger, L. (2015). Using the gugging swallowing screen (GUSS) for dysphagia screening in acute stroke patients. *Journal of continuing education in nursing, 46*(3), 103-104. doi:10.3928/00220124-20150220-12

Johnson, E. R., McKenzie, S. W., & Sievers, A. (1993). Aspiration pneumonia in stroke. *Arch.Phys.Med.Rehabil., 74*(9), 973-976.

Johnson, M. A., & Fischer, J. (2004). Eating and appetite: Common problems and practical remedies. *Generations*, *28*(3), 11-17.

Jones, B. J., Lees, R., Andrews, J., Frost, P., & Silk, D. B. (1983). Comparison of an elemental and polymeric enteral diet in patients with normal gastrointestinal function. *Gut*, *24*(1), 78-84.

Karnell, M. P., & Rogus, N. M. (2005). Comparison of Clinician Judgments and Measurements of Swallow Response Time. *Journal of Speech, Language, and Hearing Research*.

Kahrilas, P. J., Dodds, W. J., Dent, J., Wyman, J. B., Hogan, W. J., & Arndorfer, R. C. (1986). Upper esophageal sphincter function during belching. *Gastroenterology*, *91*(1), 133-140.

Kendall, K. A., & Leonard, R. J. (2001). Hyoid movement during swallowing in older patients with dysphagia. *Archives of Otolaryngology–Head & Neck Surgery*, *127*(10), 1224-1229.

Khedr, E. M., Abo-Elfetoh, N., & Rothwell, J. C. (2009). Treatment of post-stroke dysphagia with repetitive transcranial magnetic stimulation. *Acta Neurol.Scand., 119*(3), 155-161. doi:ANE1093 [pii];10.1111/j.1600-0404.2008.01093.x [doi]

Kidd, D., Lawson, J., Nesbitt, R., & MacMahon, J. (1995). The natural history and clinical consequences of aspiration in acute stroke. *QJM., 88*(6), 409-413.

Kim, H., Chung, C. S., Lee, K. H., & Robbins, J. (2000). Aspiration subsequent to a pure medullary infarction: lesion sites, clinical variables, and outcome. *Arch Neurol., 57*(4), 478-483.

Kim, S. Y., Kim, T. U., Hyun, J. K., & Lee, S. J. (2014). Differences in Videofluoroscopic Swallowing Study (VFSS) Findings According to the Vascular Territory Involved in Stroke. *Dysphagia, 29*(4), 444-449. doi:10.1007/s00455-014-9525-x

Kim, Y., & McCullough, G. H. (2007). Stage transition duration in patients poststroke. *Dysphagia*, *22*(4), 299-305.

Kimura, K., Minematsu, K., Kazui, S., & Yamaguchi, T. (2005). Mortality and cause of death after hospital discharge in 10,981 patients with ischemic stroke and transient ischemic attack. *Cerebrovascular diseases, 19*(3), 171-178.

Kimura, Y., Takahashi, M., Wada, F., & Hachisuka, K. (2013). Differences in the peak cough flow among stroke patients with and without dysphagia. *Journal of UOEH, 35*(1), 9-16. doi:10.7888/juoeh.35.9

Kjaersgaard, A., Nielsen, L. H., & Sjolund, B. H. (2014). Randomized trial of two swallowing assessment approaches in patients with acquired brain injury: Facial-Oral Tract Therapy versus Fibreoptic Endoscopic Evaluation of Swallowing. *Clinical Rehabilitation, 28*(3), 243-253. doi:10.1177/026921551350005.'

Kobayashi, H., Hoshino, M., Okayama, K., Sekizawa, K., & Sasaki, H. (1994). Swallowing and cough reflexes after onset of stroke. *CHEST-CHICAGO-*, *105*, 1623-1623.

Konecny, P., & Elfmark, M. (2018). Electrical stimulation of hyoid muscles in post-stroke dysphagia. *Biomed Pap Med Fac Univ Palacky Olomouc Czech Repub, 162*(1), 40-42. doi:10.5507/bp.2017.043

Körner, S., Hendricks, M., Kollewe, K., Zapf, A., Dengler, R., Silani, V., & Petri, S. (2013). Weight loss, dysphagia and supplement intake in patients with amyotrophic lateral sclerosis (ALS): impact on quality of life and therapeutic options. *BMC neurology*, *13*(1), 84.

Kraaijenga, S., Van Der Molen, L., Stuiver, M., Teertstra, H., Hilgers, F., & van Den Brekel, M. (2015). Effects of strengthening exercises on swallowing musculature and function in senior healthy subjects: a prospective effectiveness and feasibility study. *Dysphagia, 30*(4), 392-403.

Kramer, P., Shein, D., & Napolitano, J. (2007). Rehabilitation of speech, language and swallowing disorders. In *Acquired Brain Injury* (pp. 238-258): Springer.

Kumar, S., Doughty, C., Doros, G., Selim, M., Lahoti, S., Gokhale, S., & Schlaug, G. (2014). Recovery of Swallowing after Dysphagic Stroke: An Analysis of Prognostic Factors. *Journal of Stroke & Cerebrovascular Diseases, 23*(1), 56-62. doi:10.1016/j.jstrokecerebrovasdis.2012.09.005

Kumar, S., Wagner, C. W., Frayne, C., Zhu, L., Selim, M., Feng, W., & Schlaug, G. (2011). Noninvasive brain stimulation may improve stroke-related dysphagia: a pilot study. *Stroke, 42*(4), 1035-1040. doi:STROKEAHA.110.602128 [pii];10.1161/STROKEAHA.110.602128 [doi]

Kuptniratsaikul, V., Kovindha, A., Suethanapornkul, S., Manimmanakorn, N., & Archongka, Y. (2013). Long-term morbidities in stroke survivors: a prospective multicenter study of Thai stroke rehabilitation registry. *BMC geriatrics, 13*(1), 33.

Kushner, D. S., Peters, K., Eroglu, S. T., Perless-Carroll, M., & Johnson-Greene, D. (2013). Neuromuscular electrical stimulation efficacy in acute stroke feeding tube-dependent dysphagia during inpatient rehabilitation. *Am J Phys Med Rehabil, 92*(6), 486-495. doi:10.1097/PHM.0b013e31828762ec [doi]

Lakshminarayan, K., Tsai, A. W., Tong, X., Vazquez, G., Peacock, J. M., George, M. G., . . . Anderson, D. C. (2010). Utility of dysphagia screening results in predicting poststroke pneumonia. *Stroke, 41*(12), 2849-2854. doi:STROKEAHA.110.597039 [pii];10.1161/STROKEAHA.110.597039 [doi]

Langdon, C., & Blacker, D. (2010). Dysphagia in stroke: a new solution. *Stroke research and treatment, 2010*.

Langdon, P. C., Lee, A. H., & Binns, C. W. (2009). High incidence of respiratory infections in 'nil by mouth' tube-fed acute ischemic stroke patients. *Neuroepidemiology, 32*(2), 107-113. doi:000177036 [pii];10.1159/000177036 [doi]

Langmore, S. E., Terpenning, M. S., Schork, A., Chen, Y., Murray, J. T., Lopatin, D., & Loesche, W. J. (1998). Predictors of aspiration pneumonia: how important is dysphagia? *Dysphagia, 13*(2), 69-81.

Landi, F., Russo, A., Liperoti, R., Pahor, M., Tosato, M., Capoluongo, E., ... & Onder, G. (2010). Midarm muscle circumference, physical performance and mortality: results from the aging and longevity study in the Sirente geographic area (ilSIRENTE study). *Clinical Nutrition*, *29*(4), 441-447.

Leder, S. B., & Espinosa, J. F. (2002). Aspiration risk after acute stroke: comparison of clinical examination and fiberoptic endoscopic evaluation of swallowing. *Dysphagia, 17*(3), 214-218. doi:10.1007/s00455-002-0054-7 [doi]

Lee, J. H., Lee, K. W., Kim, S. B., Lee, S. J., Chun, S. M., & Jung, S. M. (2016). The functional dysphagia scale is a useful tool for predicting aspiration pneumonia in patients with Parkinson disease. *Annals of rehabilitation medicine*, *40*(3), 440.

Lee, J. Y., Kim, D. K., Seo, K. M., & Kang, S. H. (2014). Usefulness of the simplified cough test in evaluating cough reflex sensitivity as a screening test for silent aspiration. *Annals of Rehabilitation Medicine, 38*(4), 476-484. doi:10.5535/arm.2014.38.4.476

Lee, K. W., Kim, S. B., Lee, J. H., Lee, S. J., Ri, J. W., & Park, J. G. (2014). The effect of early neuromuscular electrical stimulation therapy in acute/subacute ischemic stroke patients with dysphagia. *Annals of Rehabilitation Medicine, 38*(2), 153-159. doi:10.5535/arm.2014.38.2.153

Li, S., Ma, Z., Tu, S., Zhou, M., Chen, S., Guo, Z., . . . Yao, D. (2014). Altered resting-state functional and white matter tract connectivity in stroke patients with dysphagia. *Neurorehabilitation and Neural Repair, 28*(3), 260-272.

Li, S., Zhou, M., Yu, B., Ma, Z., Chen, S., Gong, Q., . . . Wang, X. (2014). Altered default mode and affective network connectivity in stroke patients with and without dysphagia. *Journal of Rehabilitation Medicine, 46*(2), 126-131.

Li, W., Kang, X., Ren, J. L., Lai, X. Z., & Tai, L. W. (2017). Effects of extended in-patient treatment training on outcome of post-stroke dysphagia. *Eur Rev Med Pharmacol Sci, 21*(24), 5711-5716. doi:10.26355/eurrev_201712_14017

Liao, X., Xing, G., Guo, Z., Jin, Y., Tang, Q., He, B., . . . Mu, Q. (2017). Repetitive transcranial magnetic stimulation as an alternative therapy for dysphagia after stroke: a systematic review and meta-analysis. *Clinical Rehabilitation, 31*(3), 289-298.

Lichtman, S. W., Birnbaum, I. L., Sanfilippo, M. R., Pellicone, J. T., Damon, W. J., & King, M. L. (1995). Effect of a tracheostomy speaking valve on secretions, arterial oxygenation, and

olfaction: a quantitative evaluation. *Journal of Speech, Language, and Hearing Research, 38*(3), 549-555.
Lim, K. B., Lee, H. J., Lim, S. S., & Choi, Y. I. (2009). Neuromuscular electrical and thermal-tactile stimulation for dysphagia caused by stroke: a randomized controlled trial. *J.Rehabil.Med., 41*(3), 174-178. doi:10.2340/16501977-0317 [doi]
Lim, S. H., Lieu, P., Phua, S., Seshadri, R., Venketasubramanian, N., Lee, S., & Choo, P. W. (2001). Accuracy of bedside clinical methods compared with fiberoptic endoscopic examination of swallowing (FEES) in determining the risk of aspiration in acute stroke patients. *Dysphagia, 16*(1), 1-6.
Lin, W. S., Chou, C. L., Chang, M. H., Chung, Y. M., Lin, F. G., & Tsai, P. Y. (2018). Vagus nerve magnetic modulation facilitates dysphagia recovery in patients with stroke involving the brainstem - A proof of concept study. *Brain Stimul, 11*(2), 264-270. doi:10.1016/j.brs.2017.10.021
Linden, P., & Siebens, A. A. (1983). Dysphagia: predicting laryngeal penetration. *Arch.Phys.Med.Rehabil., 64*(6), 281-284.
Lo, Y. L., Cui, S., & Fook-Chong, S. (2005). The effect of acupuncture on motor cortex excitability and plasticity. *Neuroscience letters, 384*(1-2), 145-149.
Loeb, M. B., Becker, M., Eady, A., & Walker-Dilks, C. (2003). Interventions to prevent aspiration pneumonia in older adults: a systematic review. *J Am Geriatr Soc, 51*(7), 1018-1022.
Logemann, J. A. (1991). Approaches to management of disordered swallowing. *Baillière's clinical gastroenterology, 5*(2), 269-280.
Logemann, J. A. (1993). Noninvasive approaches to deglutitive aspiration. *Dysphagia, 8*(4), 331-333.
Logemann, J. A. (1997). Role of the modified barium swallow in management of patients with dysphagia. *Otolaryngology--Head and Neck Surgery, 116*(3), 335-338.
Logemann, J. A. (1998). The evaluation and treatment of swallowing disorders. *Current Opinion in Otolaryngology & Head and Neck Surgery, 6*(6), 395-400.
Logemann, J. A. (1999). Behavioral management for oropharyngeal dysphagia. *Folia phoniatrica et logopaedica, 51*(4-5), 199-212.
Logemann, J. A. (2008). Treatment of oral and pharyngeal dysphagia. *Physical medicine and rehabilitation clinics of North America, 19*(4), 803-816.
Logemann, J. A., & Logemann, J. A. (1983). Evaluation and treatment of swallowing disorders.
Logemann, J. A., Williams, R. B., Rademaker, A., Pauloski, B. R., Lazarus, C. L., & Cook, I. (2005). The relationship between observations and measures of oral and pharyngeal residue from videofluorography and scintigraphy. *Dysphagia, 20*(3), 226-231.
Maeshima, S., Osawa, A., Hayashi, T., & Tanahashi, N. (2013). *Factors Associated with Prognosis of Eating and Swallowing Disability after Stroke: A Study from a Community-based Stroke Care System. Journal of Stroke and Cerebrovascular Diseases, 22(7), 926–930.e1.* doi:10.1016/j.jstrokecerebrovasdis.2013.04.003
Malik, S. N., Khan, M. S. G., & Ehsaan, F. (2017). Effectiveness of swallow maneuvers, thermal stimulation and combination both in treatment of patients with dysphagia using functional outcome swallowing scale.
Mann, G., Hankey, G. J., & Cameron, D. (1999). Swallowing function after stroke: prognosis and prognostic factors at 6 months. *Stroke, 30*(4), 744-748.
Mansueto Mourão, A., Oliveira Almeida, E., Aguiar Lemos, S. M., Caseiro Vicente, L. C., & Teixeira, A. L. (2016). Evolução da deglutição no pós-AVC agudo: estudo descritivo. *Revista CEFAC, 18*(2).
Manzano, J. L., Lubillo, S., Henríquez, D., Martín, J. C., Pérez, M. C., & Wilson, D. J. (1993). Verbal communication of ventilator-dependent patients. *Crit Care Med, 21*(4), 512-517.

Marik, P. E. (2001). Aspiration pneumonitis and aspiration pneumonia. *New England Journal of Medicine*, *344*(9), 665-671.

Martino, R., Maki, E., & Diamant, N. (2014). Identification of dysphagia using the Toronto Bedside Swallowing Screening Test (TOR-BSST©): Are 10 teaspoons of water necessary? *International Journal of Speech-Language Pathology, 16*(3), 193-198. doi:http://dx.doi.org/10.3109/17549507.2014.902995

Martino, R., Silver, F., Teasell, R., Bayley, M., Nicholson, G., Streiner, D. L., & Diamant, N. E. (2009). The Toronto Bedside Swallowing Screening Test (TOR-BSST): development and validation of a dysphagia screening tool for patients with stroke. *Stroke, 40*(2), 555-561. doi:STROKEAHA.107.510370 [pii];10.1161/STROKEAHA.107.510370 [doi]

Martino, R., Foley, N., Bhogal, S., Diamant, N., Speechley, M., & Teasell, R. (2005). Dysphagia after stroke: incidence, diagnosis, and pulmonary complications. stroke, 36(12), 2756-2763.

Martino, R., Pron, G., & Diamant, N. (2000). Screening for oropharyngeal dysphagia in stroke: insufficient evidence for guidelines. *Dysphagia., 15*(1), 19-30.

Matsuse, T., Oka, T., Kida, K., & Fukuchi, Y. (1996). Importance of diffuse aspiration bronchiolitis caused by chronic occult aspiration in the elderly. *Chest*, *110*(5), 1289-1293.

McMicken, B. L., & Muzzy, C. L. (2009). Prognostic indicators of functional outcomes in first time documented acute stroke patients following standard dysphagia treatment. *Disability and rehabilitation, 31*(26), 2196-2203.

Md. Rashed Alam, C., Khan Abul Kalam, A., Mahmudur Rahman, S., & Saad, S. (2014). Incidence of Aspiration Pneumonia in Patients with Altered Consciousness Admitted in DMCH. *Journal of Medicine, 15*(1), 14-n/a.

Meng, N.-H., Wang, T.-G., & Lien, I.-N. (2000). Dysphagia in patients with brainstem stroke: incidence and outcome. *American journal of physical medicine & rehabilitation, 79*(2), 170-175.

Meng, P., Zhang, S., Wang, Q., Wang, P., Han, C., Gao, J., & Yue, S. (2018). The effect of surface neuromuscular electrical stimulation on patients with post-stroke dysphagia. *J Back Musculoskelet Rehabil, 31*(2), 363-370. doi:10.3233/bmr-170788

Mihai, P. G., Otto, M., Platz, T., Eickhoff, S. B., Lotze, & Martin. (2014). Sequential evolution of cortical activity and effective connectivity of swallowing using fMRI. *Human brain mapping, 35*(12), 5962-5973.

Milazzo, L. S., J., B., & D.A., L. (1989). The swallowing process: effects of aging and
stroke. *Physical Medicine and Rehabilitation: State of the Art Reviews, 3*(3), 489-499.

Miles, A., McFarlane, M., Kainth, P., & Parmar, P. (2014). Interdisciplinary management of dysphagia. *Nursing & Residential Care, 16*(10), 561-567.

Miles, A., Moore, S., McFarlane, M., Lee, F., Allen, J., & Huckabee, M. L. (2013). Comparison of cough reflex test against instrumental assessment of aspiration. *Physiology & Behavior, 118*, 25-31. doi:10.1016/j.physbeh.2013.05.004

Molfenter, S. M., & Steele, C. M. (2013). The Relationship Between Residue and Aspiration on the Subsequent Swallow: An Application of the Normalized Residue Ratio Scale. *Dysphagia, 28*(4), 494-500. doi:10.1007/s00455-013-9459-8

Momosaki, R., Abo, M., Kakuda, W., & Kobayashi, K. (2013). Applicability of the two-step thickened water test in patients with poststroke Dysphagia: a novel assessment tool for paste food aspiration. *J Stroke Cerebrovasc Dis, 22*(6), 817-821. doi:S1052-3057(12)00141-3 [pii];10.1016/j.jstrokecerebrovasdis.2012.05.011 [doi]

Momosaki, R., Abo, M., Kakuda, W., & Uruma, G. (2012). Which cortical area is related to the development of dysphagia after stroke? A single photon emission computed tomography study using novel analytic methods. *Eur.Neurol, 67*(2), 74-80. doi:000333778 [pii];10.1159/000333778 [doi]

Momosaki, R., Abo, M., Watanabe, S., Kakuda, W., Yamada, N., & Mochio, K. (2014). Influence of functional magnetic stimulation on swallowing function. *Brain Injury, 28 (5-6)*, 562.

Moon, J. H., Jung, J.-H., Won, Y. S., Cho, H.-Y., & Cho, K. (2017). Effects of expiratory muscle strength training on swallowing function in acute stroke patients with dysphagia. *Journal of physical therapy science, 29*(4), 609-612.

Morton, R., Minford, J., Ellis, R., & Pinnington, L. (2002). Aspiration with dysphagia: the interaction between oropharyngeal and respiratory impairments. *Dysphagia*, *17*(3), 192-196.

Muller-Lissner, S. A., Fimmel, C. J., Will, N., Muller-Duysing, W., Heinzel, F., & Blum, A. L. (1982). Effect of gastric and transpyloric tubes on gastric emptying and duodenogastric reflux. *Gastroenterology, 83*(6), 1276-1279. doi:S001650858200242X [pii]

Muz, J., Mathog, R. H., Hamlet, S. L., Davis, L. P., & Kling, G. A. (1991). Objective assessment of swallowing function in head and neck cancer patients. *Head & neck, 13*(1), 33-39.

Nakajoh, K., Nakagawa, T., Sekizawa, K., Matsui, T., Arai, H., & Sasaki, H. (2000). Relation between incidence of pneumonia and protective reflexes in post-stroke patients with oral or tube feeding. *J.Intern.Med., 247*(1), 39-42. doi:jim565 [pii]

Nakamura, T., & Fujishima, I. (2013). Usefulness of ice massage in triggering the swallow reflex. *J Stroke Cerebrovasc Dis, 22*(4), 378-382. doi:S1052-3057(11)00274-6 [pii];10.1016/j.jstrokecerebrovasdis.2011.09.016 [doi]

Nakayama, K., Sekizawa, K., & Sasaki, H. (1998). ACE inhibitor and swallowing reflex. *Chest, 113*(5), 1425.

Nam, H. S., Beom, J., Oh, B. M., & Han, T. R. (2013). Kinematic Effects of Hyolaryngeal Electrical Stimulation Therapy on Hyoid Excursion and Laryngeal Elevation. *Dysphagia, 28*(4), 548-556. doi:10.1007/s00455-013-9465-x

Nikhil, J., Naidu, R. K., Krishnan, G., & Manjula, R. (2014). Oral and pharyngeal transit time as a factor of age, gender, and consistency of liquid bolus. *Journal of Laryngology and Voice*, *4*(2), 45.

Norton, B., Homer-Ward, M., Donnelly, M. T., Long, R. G., & Holmes, G. K. (1996). A randomised prospective comparison of percutaneous endoscopic gastrostomy and nasogastric tube feeding after acute dysphagic stroke. *BMJ, 312*(7022), 13-16.

Odderson, I. R., Keaton, J. C., & McKenna, B. S. (1995). Swallow management in patients on an acute stroke pathway: quality is cost effective. *Arch.Phys.Med.Rehabil., 76*(12), 1130-1133. doi:S0003-9993(95)80121-9 [pii]

Ohkubo, T., Chapman, N., Neal, B., Woodward, M., Omae, T., & Chalmers, J. (2004). Effects of an angiotensin-converting enzyme inhibitor–based regimen on pneumonia risk. *American journal of respiratory and critical care medicine, 169*(9), 1041-1045.

O'Neil, K. H., Purdy, M., Falk, J., & Gallo, L. (1999). The dysphagia outcome and severity scale. *Dysphagia*, *14*(3), 139-145.

Osawa, A., Maeshima, S., & Tanahashi, N. (2013a). Efficacy of Cilostazol in Preventing Aspiration Pneumonia in Acute Cerebral Infarction. *J Stroke Cerebrovasc Dis, 22*(6), 857-861. doi:S1052-3057(12)00201-7 [pii];10.1016/j.jstrokecerebrovasdis.2012.06.008 [doi]

Osawa, A., Maeshima, S., & Tanahashi, N. (2013b). Water-swallowing test: screening for aspiration in stroke patients. *Cerebrovasc Dis, 35*(3), 276-281. doi:000348683 [pii];10.1159/000348683 [doi]

Park, C. S. (2018). The test-retest reliability and minimal detectable change of the short-form Barthel Index (5 items) and its associations with chronic stroke-specific impairments. *Journal of physical therapy science*, *30*(6), 835-839.

Park, E., Kim, M. S., Chang, W. H., Oh, S. M., Kim, Y. K., Lee, A., & Kim, Y. H. (2017). Effects of Bilateral Repetitive Transcranial Magnetic Stimulation on Post-Stroke Dysphagia. *Brain Stimul, 10*(1), 75-82. doi:10.1016/j.brs.2016.08.005

Park, G. Y., Kim, S. R., Kim, Y. W., Jo, K. W., Lee, E. J., Kim, Y. M., & Im, S. (2015). Decreased Diaphragm Excursion in Stroke Patients With Dysphagia as Assessed by M-Mode Sonography. *Archives of physical medicine and rehabilitation, 96*(1), 114-121. doi:10.1016/j.apmr.2014.08.019

Park, J. S., An, D. H., Oh, D. H., & Chang, M. Y. (2018). Effect of chin tuck against resistance exercise on patients with dysphagia following stroke: A randomized pilot study. *NeuroRehabilitation, 42*(2), 191-197. doi:10.3233/nre-172250

Park, J. S., Oh, D. H., & Chang, M. (2016). Comparison of maximal tongue strength and tongue strength used during swallowing in relation to age in healthy adults. *Journal of physical therapy science*, *28*(2), 442-445.

Park, J. S., Oh, D. H., Chang, M. Y., & Kim, K. M. (2016). Effects of expiratory muscle strength training on oropharyngeal dysphagia in subacute stroke patients: a randomised controlled trial. *J Oral Rehabil, 43*(5), 364-372. doi:10.1111/joor.12382

Park, J. S., Oh, D. H., Hwang, N. K., & Lee, J. H. (2016). Effects of neuromuscular electrical stimulation combined with effortful swallowing on post-stroke oropharyngeal dysphagia: A randomised controlled trial. *J Oral Rehabil, 43*(6), 426-434. doi:10.1111/joor.12390

Park, J. W., Oh, J. C., Lee, J. W., Yeo, J. S., & Ryu, K. H. (2013). The effect of 5Hz high-frequency rTMS over contralesional pharyngeal motor cortex in post-stroke oropharyngeal dysphagia: a randomized controlled study. *Neurogastroenterol.Motil., 25*(4), 324-e250. doi:10.1111/nmo.12063 [doi]

Park, R. H., Allison, M. C., Lang, J., Spence, E., Morris, A. J., Danesh, B. J., . . . Mills, P. R. (1992). Randomised comparison of percutaneous endoscopic gastrostomy and nasogastric tube feeding in patients with persisting neurological dysphagia. *BMJ, 304*(6839), 1406-1409.

Passy-Muir Incorporated. (2004). Passy-Muir Clinical Inservice Outline. from http://www.passymuir.com/pdfs/inservice_outline.pdf

Passy, V., Baydur, A., Prentice, W., & Darnell-Neal, R. (1993). Passy-Muir tracheostomy speaking valve on ventilator-dependent patients. *The Laryngoscope, 103*(6), 653-658.

Patti, M. G., Goldberg, H. I., Arcerito, M., Bortolasi, L., Tong, J., & Way, L. W. (1996). Hiatal hernia size affects lower esophageal sphincter function, esophageal acid exposure, and the degree of mucosal injury. *The American journal of surgery*, *171*(1), 182-186.

Pearson, W. G., Molfenter, S. M., Smith, Z. M., & Steele, C. M. (2013). Image-based measurement of post-swallow residue: the normalized residue ratio scale. *Dysphagia*, *28*(2), 167-177.

Permsirivanich, W., Tipchatyotin, S., Wongchai, M., Leelamanit, V., Setthawatcharawanich, S., Sathirapanya, P., . . . Boonmeeprakob, A. (2009). Comparing the effects of rehabilitation swallowing therapy vs. neuromuscular electrical stimulation therapy among stroke patients with persistent pharyngeal dysphagia: a randomized controlled study. *J.Med.Assoc.Thai., 92*(2), 259-265.

Perrier, E., Rondeau, P., Poupin, M., Le Bellego, L., Armstrong, L. E., Lang, F., ... & Klein, A. (2013). Relation between urinary hydration biomarkers and total fluid intake in healthy adults. *European journal of clinical nutrition*, *67*(9), 939.

Perry, A. (2004). Therapy outcome measures for allied health practitioners in Australia: the AusTOMs. International Journal for Quality in Health Care, 16(4), 285–291. doi:10.1093/intqhc/mzh059

Pikosky, M. A., Smith, T. J., Grediagin, A. N. N., Castaneda-Sceppa, C., Byerley, L., Glickman, E. L., & Young, A. J. (2008). Increased protein maintains nitrogen balance during exercise-induced energy deficit. *Medicine & Science in Sports & Exercise*, *40*(3), 505-512.

Platt, J. (2001). Dysphagia management for long-term care: A manual for nurses and other healthcare professionals. Clinical and Educational Services

Policy, U. S. A. f. H. C., & ECRI. (1999). *Diagnosis and treatment of swallowing disorders (dysphagia) in acute-care stroke patients*: AHCPR Publication.

Polkey, M. I., Luo, Y., Guleria, R., ÅRD, C.-H. H., Green, M., & Moxham, J. (1999). Functional magnetic stimulation of the abdominal muscles in humans. *American journal of respiratory and critical care medicine, 160*(2), 513-522.

Power, M. L., Fraser, C. H., Hobson, A., Singh, S., Tyrrell, P., Nicholson, D. A., . . . Hamdy, S. (2006). Evaluating oral stimulation as a treatment for dysphagia after stroke. *Dysphagia, 21*(1), 49-55. doi:10.1007/s00455-005-9009-0 [doi]

Quinn, T. J., Dawson, J., Walters, M., & Lees, K. R. (2009). Reliability of the modified Rankin Scale: a systematic review. *Stroke*, *40*(10), 3393-3395.

Rabinstein, A. A., & Shulman, L. M. (2003). Acupuncture in clinical neurology. *The neurologist, 9*(3), 137-148.

Ramsey, D. J., Smithard, D. G., & Kalra, L. (2003). Early assessments of dysphagia and aspiration risk in acute stroke patients. *Stroke, 34*(5), 1252-1257. doi:10.1161/01.STR.0000066309.06490.B8 [doi];01.STR.0000066309.06490.B8 [pii]

Restivo, D. A., & Hamdy, S. (2018). Pharyngeal electrical stimulation device for the treatment of neurogenic dysphagia: technology update. *Medical devices (Auckland, NZ), 11*, 21.

Reynolds, P. S., Gilbert, L., Good, D. C., Knappertz, V. A., Crenshaw, C., Wayne, S. L., . . . Tegeler, C. H. (1998). Pneumonia in dysphagic stroke patients: effect on outcomes and identification of high risk patients. *Journal of Neurologic Rehabilitation, 12*(1), 15-21.

Robbins, J., Levine, R. L., Maser, A., Rosenbek, J. C., & Kempster, G. B. (1993). Swallowing after unilateral stroke of the cerebral cortex. *Arch.Phys.Med.Rehabil., 74*(12), 1295-1300. doi:0003-9993(93)90082-L [pii]

Rofes, L., Arreola, V., Lopez, I., Martin, A., Sebastian, M., Ciurana, A., & Clave, P. (2013). Effect of surface sensory and motor electrical stimulation on chronic poststroke oropharyngeal dysfunction. *Neurogastroenterology and Motility, 25*(11), 888-E701. doi:10.1111/nmo.12211

Rolland-Cachera, M. F., Brambilla, P., Manzoni, P., Akrout, M., Sironi, S., Del Maschio, A., & Chiumello, G. (1997). Body composition assessed on the basis of arm circumference and triceps skinfold thickness: a new index validated in children by magnetic resonance imaging. *The American journal of clinical nutrition*, *65*(6), 1709-1713.

Rosenbek, J. C., Robbins, J., Willford, W. O., Kirk, G., Schiltz, A., Sowell, T. W., . . . Gramigna, G. D. (1998). Comparing treatment intensities of tactile-thermal application. *Dysphagia, 13*(1), 1-9.

Rosenbek, J. C., Roecker, E. B., Wood, J. L., & Robbins, J. (1996). Thermal application reduces the duration of stage transition in dysphagia after stroke. *Dysphagia, 11*(4), 225-233.

Rowat, A. M., Wardlaw, J. M., Dennis, M. S., & Warlow, C. P. (2000). Does feeding alter arterial oxygen saturation in patients with acute stroke? *Stroke, 31*(9), 2134-2140.

Ruohonen, J., Ravazzani, P., & Grandori, F. (1998). Functional magnetic stimulation: theory and coil optimization. *Bioelectrochemistry and Bioenergetics, 47*(2), 213-219.

Ryu, J. S., Park, S. R., & Choi, K. H. (2004). Prediction of laryngeal aspiration using voice analysis. *Am.J.Phys.Med.Rehabil., 83*(10), 753-757. doi:00002060-200410000-00002 [pii]

Sato, M., Tohara, H., Iida, T., Wada, S., Inoue, M., & Ueda, K. (2012). Simplified cough test for screening silent aspiration. *Archives of physical medicine and rehabilitation, 93*(11), 1982-1986.

Satou, Y., Oguro, H., Murakami, Y., Onoda, K., Mitaki, S., Hamada, C., . . . Yamaguchi, S. (2013). Gastroesophageal reflux during enteral feeding in stroke patients: a 24-hour esophageal pH-monitoring study. *J Stroke Cerebrovasc Dis, 22*(3), 185-189. doi:S1052-3057(11)00200-X [pii];10.1016/j.jstrokecerebrovasdis.2011.07.008 [doi]

Schmidt, J., Holas, M., Halvorson, K., & Reding, M. (1994). Videofluoroscopic evidence of aspiration predicts pneumonia and death but not dehydration following stroke. *Dysphagia., 9*(1), 7-11.

Sekizawa, K., Jia, Y. X., Ebihara, T., Hirose, Y., Hirayama, Y., & Sasaki, H. (1996). Role of substance P in cough. *Pulmonary pharmacology, 9*(5-6), 323-328.

Sekizawa, K., Matsui, T., Nakagawa, T., Nakayama, K., & Sasaki, H. (1998). ACE inhibitors and pneumonia. *The Lancet, 352*(9133), 1069.

Sellars, C., Bowie, L., Bagg, J., Sweeney, M. P., Miller, H., Tilston, J., . . . Stott, D. J. (2007). Risk factors for chest infection in acute stroke: a prospective cohort study. *Stroke., 38*(8), 2284-2291.

Sellars, C., Dunnet, C., & Carter, R. (1998). A preliminary comparison of videofluoroscopy of swallow and pulse oximetry in the identification of aspiration in dysphagic patients. *Dysphagia, 13*(2), 82-86.

Shaker, R., Easterling, C., Kern, M., Nitschke, T., Massey, B., Daniels, S., . . . Dikeman, K. (2002). Rehabilitation of swallowing by exercise in tube-fed patients with pharyngeal dysphagia secondary to abnormal UES opening. *Gastroenterology, 122*(5), 1314-1321.

Shaker, R., Kern, M., Bardan, E., Taylor, A., Stewart, E. T., Hoffmann, R. G., . . . Bonnevier, J. (1997). Augmentation of deglutitive upper esophageal sphincter opening in the elderly by exercise. *American Journal of Physiology-Gastrointestinal and Liver Physiology, 272*(6), G1518-G1522.

Sharma, J. C., Fletcher, S., Vassallo, M., & Ross, I. (2001). What influences outcome of stroke--pyrexia or dysphagia? *Int.J.Clin Pract., 55*(1), 17-20.

Shaw, D. W., Cook, I. J., Gabb, M., Holloway, R. H., Simula, M. E., Panagopoulos, V., & Dent, J. (1995). Influence of normal aging on oral-pharyngeal and upper esophageal sphincter function during swallowing. *American Journal of Physiology-Gastrointestinal and Liver Physiology*, *268*(3), G389-G396.

Shaw, D., Williams, R., Cook, I., Wallace, K., Weltman, M., Collins, P., . . . Simula, M. (2004). Oropharyngeal scintigraphy: a reliable technique for the quantitative evaluation of oral–pharyngeal swallowing. *Dysphagia, 19*(1), 36-42.

Shaw, J. L., Sharpe, S., Dyson, S. E., Pownall, S., Walters, S., Saul, C., ... & O'Sullivan, H. (2004). Bronchial auscultation: an effective adjunct to speech and language therapy bedside assessment when detecting dysphagia and aspiration?. Dysphagia, 19(4), 211-218.

Sherman, B. S., Webster, I. T., Jones, G. J., & Oliver, R. L. (1998). Transitions between Auhcoseira and Anabaena dominance in a turbid river weir pool. *Limnology and Oceanography, 43*(8), 1902-1915.

Shigematsu, T., Fujishima, I., & Ohno, K. (2013). Transcranial direct current stimulation improves swallowing function in stroke patients. *Neurorehabil Neural Repair, 27*(4), 363-369. doi:1545968312474116 [pii];10.1177/1545968312474116 [doi]

Shinohara, Y. (2006). Antiplatelet cilostazol is effective in the prevention of pneumonia in ischemic stroke patients in the chronic stage. *Cerebrovascular diseases, 22*(1), 57-60.

Shinohara, Y., & Origasa, H. (2012). Post-stroke pneumonia prevention by angiotensin-converting enzyme inhibitors: results of a meta-analysis of five studies in Asians. *Advances in therapy*, 1-13.

Shoji, H., Yamamoto, T., Inoue, T., Oikawa, C., Adachi, N., Shintani, S., & Hino, T. (2010). Creating Flowcharts of Eating and Swallowing. *Journal of the Japanese Association of Rural Medicine, 58*(5), 526-532. doi:10.2185/jjrm.58.526

Shore, S., Stimler-Gerard, N., Coats, S., & Drazen, J. (1988). Substance P-induced bronchoconstriction in the guinea pig: enhancement by inhibitors of neutral metalloendopeptidase and angiotensin-converting enzyme. *American Review of Respiratory Disease, 137*(2), 331-336.

Silver, F. L., Norris, J. W., Lewis, A. J., & Hachinski, V. C. (1984). Early mortality following stroke: a prospective review. *Stroke, 15*(3), 492-496.

Silver, K. H., & Van Nostrand, D. (1992). Scintigraphic detection of salivary aspiration: description of a new diagnostic technique and case reports. *Dysphagia, 7*(1), 45-49.

Smith, H. A., Lee, S. H., O'Neill, P. A., & Connolly, M. J. (2000). The combination of bedside swallowing assessment and oxygen saturation monitoring of swallowing in acute stroke: a safe and humane screening tool. *Age Ageing, 29*(6), 495-499.

Smithard, D. G., O'Neill, P. A., Parks, C., & Morris, J. (1996). Complications and outcome after acute stroke. Does dysphagia matter? *Stroke, 27*(7), 1200-1204.

Smithard, D. G., Smeeton, N. C., & Wolfe, C. D. (2007). Long-term outcome after stroke: does dysphagia matter? *Age Ageing, 36*(1), 90-94. doi:afl149 [pii];10.1093/ageing/afl149 [doi]

Somasundaram, S., Henke, C., Neumann-Haefelin, T., Isenmann, S., Hattingen, E., Lorenz, M. W., & Singer, O. C. (2014). Dysphagia Risk Assessment in Acute Left-Hemispheric Middle Cerebral Artery Stroke. *Cerebrovascular diseases, 37*(3), 217-222. doi:10.1159/000358118

Sorensen, R. T., Rasmussen, R. S., Overgaard, K., Lerche, A., Johansen, A. M., & Lindhardt, T. (2013). Dysphagia screening and intensified oral hygiene reduce pneumonia after stroke. *J Neurosci Nurs, 45*(3), 139-146. doi:10.1097/JNN.0b013e31828a412c [doi];01376517-201306000-00005 [pii]

Splaingard, M. L., Hutchins, B., Sulton, L. D., & Chaudhuri, G. (1988). Aspiration in rehabilitation patients: videofluoroscopy vs bedside clinical assessment. *Arch.Phys.Med.Rehabil., 69*(8), 637-640.

Stachler, R. J., Hamlet, S. L., Choi, J., & Fleming, S. (1996). Scintigraphic quantification of aspiration reduction with the Passy-Muir valve. *The Laryngoscope, 106*(2), 231-234.

Steele, C. M. (2002). Emergency room assessment and intervention for dysphagia: A pilot project.

Steele, C. M., Bayley, M. T., Peladeau-Pigeon, M., Nagy, A., Namasivayam, A. M., Stokely, S. L., & Wolkin, T. (2016). A Randomized Trial Comparing Two Tongue-Pressure Resistance Training Protocols for Post-Stroke Dysphagia. *Dysphagia, 31*(3), 452-461. doi:10.1007/s00455-016-9699-5

Steele, C. M., Namasivayam-MacDonald, A. M., Guida, B. T., Cichero, J. A., Duivestein, J., Hanson, B., . . . Riquelme, L. F. (2018). Creation and initial validation of the international dysphagia diet standardisation initiative functional diet scale. *Archives of physical medicine and rehabilitation, 99*(5), 934-944.

Stineman, M. G., Shea, J. A., Jette, A., Tassoni, C. J., Ottenbacher, K. J., Fiedler, R., & Granger, C. V. (1996). The Functional Independence Measure: tests of scaling assumptions, structure, and reliability across 20 diverse impairment categories. *Archives of physical medicine and rehabilitation*, *77*(11), 1101-1108.

Suiter, D. M., McCullough, G. H., & Powell, P. W. (2003). Effects of cuff deflation and one-way tracheostomy speaking valve placement on swallow physiology. *Dysphagia, 18*(4), 284-292.

Sun, S. F., Hsu, C. W., Lin, H. S., Sun, H. P., Chang, P. H., Hsieh, W. L., & Wang, J. L. (2013). Combined Neuromuscular Electrical Stimulation (NMES) with Fiberoptic Endoscopic Evaluation of Swallowing (FEES) and Traditional Swallowing Rehabilitation in the Treatment of Stroke-Related Dysphagia. *Dysphagia, 28*(4), 557-566. doi:10.1007/s00455-013-9466-9

Suntrup-Krueger, S., Ringmaier, C., Muhle, P., Wollbrink, A., Kemmling, A., Hanning, U., . . . Dziewas, R. (2018). Randomized trial of transcranial direct current stimulation for poststroke dysphagia. *Ann Neurol, 83*(2), 328-340. doi:10.1002/ana.25151

Sze, W. P., Yoon, W. L., Escoffier, N., & Liow, S. J. R. (2016). Evaluating the training effects of two swallowing rehabilitation therapies using surface electromyography—Chin tuck against resistance (CTAR) exercise and the Shaker exercise. *Dysphagia, 31*(2), 195-205.
Takizawa, C., Gemmell, E., Kenworthy, J., & Speyer, R. (2016). A systematic review of the prevalence of oropharyngeal dysphagia in stroke, Parkinson's disease, Alzheimer's disease, head injury, and pneumonia. Dysphagia, 31(3), 434-441.
Teasell, R., Foley, N., Fisher, J., & Finestone, H. (2002). The incidence, management, and complications of dysphagia in patients with medullary strokes admitted to a rehabilitation unit. *Dysphagia, 17*(2), 115-120.
Teasell, R. W., Bach, D., & McRae, M. (1994). Prevalence and recovery of aspiration poststroke: a retrospective analysis. *Dysphagia, 9*(1), 35-39.
Teasell, R. W., McRae, M., Marchuk, Y., & Finestone, H. M. (1996). Pneumonia associated with aspiration following stroke. *Arch.Phys.Med.Rehabil., 77*(7), 707-709. doi:S0003-9993(96)90012-X [pii]
Teramoto, S., & Fukuchi, Y. (2000). Detection of aspiration and swallowing disorder in older stroke patients: simple swallowing provocation test versus water swallowing test. *Arch.Phys.Med.Rehabil., 81*(11), 1517-1519. doi:S0003-9993(00)34233-2 [pii];10.1053/apmr.2000.9171 [doi]
Teramoto, S., Matsuse, T., Matsui, H., Ohga, E., Saitoh, E., Ishii, T., . . . Ouchi, Y. (1999). The simple swallowing provocation test as a means of screening for swallowing disorders: a comparison with the water swallowing test. *Nihon Kokyuki Gakkai zasshi= the journal of the Japanese Respiratory Society, 37*(6), 466-470.
Terpenning, M. S., Taylor, G. W., Lopatin, D. E., Kerr, C. K., Dominguez, B. L., & Loesche, W. J. (2001). Aspiration pneumonia: dental and oral risk factors in an older veteran population. *J Am Geriatr Soc, 49*(5), 557-563.
Terre, R., & Mearin, F. (2006). Oropharyngeal dysphagia after the acute phase of stroke: predictors of aspiration. *Neurogastroenterol.Motil., 18*(3), 200-205. doi:NMO729 [pii];10.1111/j.1365-2982.2005.00729.x [doi]
Tobin, M. J. (1986). Aspiration pneumonia. *Cardiopulmonary Critical Care.Orlando, FL: Grune and Stratton*.
Tomii, Y., Matsuoka, H., Torii, T., Uehara, T., Toyoda, K., & Minematsu, K. (2011). A new ultrasound method for evaluating dysphagia in acute stroke patients. *Int J Stroke, 6*(3), 279-280. doi:10.1111/j.1747-4949.2011.00603.x
Tran, P., & Mannen, J. (2009). Improving oral healthcare: improving the quality of life for patients after a stroke. *Special Care in Dentistry, 29*(5), 218-221.
Trapl, M., Enderle, P., Nowotny, M., Teuschl, Y., Matz, K., Dachenhausen, A., & Brainin, M. (2007). Dysphagia bedside screening for acute-stroke patients: the Gugging Swallowing Screen. *Stroke, 38*(11), 2948-2952. doi:STROKEAHA.107.483933 [pii];10.1161/STROKEAHA.107.483933 [doi]
Umay, E. K., Yaylaci, A., Saylam, G., Gundogdu, I., Gurcay, E., Akcapinar, D., & Kirac, Z. (2017). The effect of sensory level electrical stimulation of the masseter muscle in early stroke patients with dysphagia: A randomized controlled study. *Neurol India, 65*(4), 734-742. doi:10.4103/neuroindia.NI_377_16
Vasant, D. H., Michou, E., O'Leary, N., Vail, A., Mistry, S., & Hamdy, S. (2016). Pharyngeal Electrical Stimulation in Dysphagia Poststroke: A Prospective, Randomized Single-Blinded Interventional Study. *Neurorehabil Neural Repair, 30*(9), 866-875. doi:10.1177/1747493016643553
10.1177/1545968316639129
Veis, S. L., & Logemann, J. A. (1985). Swallowing disorders in persons with cerebrovascular accident. *Archives of physical medicine and rehabilitation, 66*(6), 372.

Veldee, M. S., & Peth, L. D. (1992). Can protein-calorie malnutrition cause dysphagia? *Dysphagia, 7*(2), 86-101.
Voyvoda, N., Yücel, C., Karataş, G., Oğuzülgen, İ., & Oktar, S. (2012). An evaluation of diaphragmatic movements in hemiplegic patients. *The British journal of radiology, 85*(1012), 411-414.
Wang, T. G., Chang, Y. C., Chen, S. Y., & Hsiao, T. Y. (2005). Pulse oximetry does not reliably detect aspiration on videofluoroscopic swallowing study. *Arch.Phys.Med.Rehabil., 86*(4), 730-734. doi:S0003999304013097 [pii];10.1016/j.apmr.2004.10.021 [doi]
Warnecke, T., Teismann, I., Meimann, W., Olenberg, S., Zimmermann, J., Kramer, C., . . . Dziewas, R. (2008). Assessment of aspiration risk in acute ischaemic stroke--evaluation of the simple swallowing provocation test. *J.Neurol.Neurosurg.Psychiatry, 79*(3), 312-314. doi:79/3/312 [pii];10.1136/jnnp.2007.134551 [doi]
Warnecke, T., Teismann, I., Oelenberg, S., Hamacher, C., Ringelstein, E. B., Schabitz, W. R., & Dziewas, R. (2009). The safety of fiberoptic endoscopic evaluation of swallowing in acute stroke patients. *Stroke, 40*(2), 482-486. doi:STROKEAHA.108.520775 [pii];10.1161/STROKEAHA.108.520775 [doi]
Warusevitane, A., Karunatilake, D., Sim, J., Lally, F., & Roffe, C. (2014). Safety and effect of metoclopramide to prevent pneumonia in patients with stroke fed via nasogastric tubes trial. *Stroke, 46*(2), 454-460.
Watanabe, S., Shimozato, K., Oh-Shige, H., Umemura, M., Fujiwara, S., Abe, Y., . . . Oh-Iwa, I. (2014). Examination of factors associated with aspiration pneumonia following stroke. *Oral Science International, 11*(1), 15-21. doi:10.1016/S1348-8643(13)00009-8
Waxman, M. J., Durfee, D., Moore, M., Morantz, R. A., & Koller, W. (1990). Nutritional aspects and swallowing function of patients with Parkinson's disease. *Nutrition in clinical practice*, *5*(5), 196-199.
Wei, X., Yu, F., Dai, M., Xie, C., Wan, G., Wang, Y., & Dou, Z. (2017). Change in Excitability of Cortical Projection After Modified Catheter Balloon Dilatation Therapy in Brainstem Stroke Patients with Dysphagia: A Prospective Controlled Study. *Dysphagia, 32*(5), 645-656. doi:10.1007/s00455-017-9810-6
Wilson, J. L., Hareendran, A., Grant, M., Baird, T., Schulz, U. G., Muir, K. W., & Bone, I. (2002). Improving the assessment of outcomes in stroke: use of a structured interview to assign grades on the modified Rankin Scale. *Stroke*, *33*(9), 2243-2246.
Wilson, R. D., & Howe, E. C. (2012). A cost-effectiveness analysis of screening methods for dysphagia after stroke. *PM.R., 4*(4), 273-282. doi:S1934-1482(11)01281-0 [pii];10.1016/j.pmrj.2011.09.006 [doi]
Winstein, C. J. (1983). Neurogenic dysphagia: frequency, progression, and outcome in adults following head injury. *Physical therapy, 63*(12), 1992-1997.
Wu, M.-T., Sheen, J.-M., Chuang, K.-H., Yang, P., Chin, S.-L., Tsai, C.-Y., . . . Chu, K.-A. (2002). Neuronal specificity of acupuncture response: a fMRI study with electroacupuncture. *Neuroimage, 16*(4), 1028-1037.
Xia, W., Zheng, C., Lei, Q., Tang, Z., Hua, Q., Zhang, Y., & Zhu, S. (2011). Treatment of post-stroke dysphagia by vitalstim therapy coupled with conventional swallowing training. *J.Huazhong.Univ Sci.Technolog.Med.Sci., 31*(1), 73-76. doi:10.1007/s11596-011-0153-5 [doi]
Xia, W., Zheng, C., Zhu, S., & Tang, Z. (2016). Does the addition of specific acupuncture to standard swallowing training improve outcomes in patients with dysphagia after stroke? a randomized controlled trial. *Clin Rehabil, 30*(3), 237-246. doi:10.1177/0269215515578698
Yamaya, M., Yanai, M., Ohrui, T., Arai, H., Sekizawa, K., & Sasaki, H. (2001). Antithrombotic therapy for prevention of pneumonia. *J Am Geriatr Soc, 49*(5), 687-688.

Yang, E. J., Baek, S. R., Shin, J., Lim, J. Y., Jang, H. J., Kim, Y. K., & Paik, N. J. (2012). Effects of transcranial direct current stimulation (tDCS) on post-stroke dysphagia. *Restor.Neurol Neurosci, 30*(4), 303-311. doi:J7N80753G0627G21 [pii];10.3233/RNN-2012-110213 [doi]

Yavagal, D. R., Karnad, D. R., & Oak, J. L. (2000). Metoclopramide for preventing pneumonia in critically ill patients receiving enteral tube feeding: a randomized controlled trial. *Crit Care Med, 28*(5), 1408-1411.

Yeh, S. J., Huang, K. Y., Wang, T. G., Chen, Y. C., Chen, C. H., Tang, S. C., . . . Jeng, J. S. (2011). Dysphagia screening decreases pneumonia in acute stroke patients admitted to the stroke intensive care unit. *J.Neurol.Sci., 306*(1-2), 38-41. doi:S0022-510X(11)00182-1 [pii];10.1016/j.jns.2011.04.001 [doi]

Yoon, W. L., Khoo, J. K. P., & Liow, S. J. R. (2014). Chin tuck against resistance (CTAR): new method for enhancing suprahyoid muscle activity using a Shaker-type exercise. *Dysphagia, 29*(2), 243-248.

Zhang, J., Zhou, Y., Wei, N., Yang, B., Wang, A., Zhou, H., ... & Villegas, B. (2016). Laryngeal elevation velocity and aspiration in acute ischemic stroke patients. *PloS one*, *11*(9), e0162257.

Zhang, M., Tao, T., Zhang, Z. B., Zhu, X., Fan, W. G., Pu, L. J., . . . Yue, S. W. (2016). Effectiveness of Neuromuscular Electrical Stimulation on Patients With Dysphagia With Medullary Infarction. *Arch Phys Med Rehabil, 97*(3), 355-362. doi:10.1016/j.apmr.2015.10.104

Zhang, N., Miyamoto, N., Tanaka, R., Mochizuki, H., Hattori, N., & Urabe, T. (2009). Activation of tyrosine hydroxylase prevents pneumonia in a rat chronic cerebral hypoperfusion model. *Neuroscience, 158*(2), 665-672. doi:10.1016/j.neuroscience.2008.10.049

Zheng, T., Zhu, X., Liang, H., Huang, H., Yang, J., & Wang, S. (2015). Impact of early enteral nutrition on short term prognosis after acute stroke. *Journal of Clinical Neuroscience, 22*(9), 1473-1476. doi:10.1016/j.jocn.2015.03.028