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Dysphagia and Aspiration Following Stroke

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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.

Key Points

- There are four sequentially coordinated phases involved in normal swallowing; oral preparatory, oral propulsive, pharyngeal and esophageal.
- Dysphagia is characterized by reduced coordination of pharyngeal 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 dysphasic symptomology.
- 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.
- 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.
- There is a wide range of the incidence of dysphagia following acute stroke and large variety of potential indicators. Further research is required.
- The prognosis of dysphagia in acute stroke is complicated and associated with many variables. Further research is required to investigate additional indicators.
- 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.
- The risk of developing pneumonia increases in patients with dysphagia and aspiration.
- Further research is required to determine the best tools for the prediction, identification and treatment of pneumonia.
- 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.
- 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.
- 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.
- There is a wide range in the validity and clinical usefulness of bedside clinical examinations. Further research is required.
- There are a number of alternative screening and assessment tests are available for use. Further research is required to test their validity in a clinical setting.

- 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.
- Scintigraphy may be a valid tool for the detection of aspiration and penetration in dysphagia. Further research is required.
- Flexible endoscopic evaluation of swallowing may reduce the incidence of pneumonia and improve other important factors associated wtih dysphagia recovery; however, the evidence is limited and further research is required.
- It is unclear whether pulse oximetry is a clinically viable tool for the detection of dysphagia and aspiration following stroke. Further research is required.
- Further research is needed to determine whether ultrasonography or videofluoroscopy are valuable tools for determining swallowing function in dysphasic patients
- Thicker liquids enhance the safety of swallowing and reduce the incidence of pneumonia. Thinner fluid consumption may increase the total fluid intake and hydration; however, they also increase the incidence of aspiration pneumonia.
- More research is needed to determine the benefit of high intensity swallowing therapy with dietary prescription at improving swallowing ability and return to a normal diet in patients with dysphagia post stroke.
- Acupuncture combined with physical therapy can be an effective treatment for dysphagia, however more research is required to strengthen this treatment protocol.
- Some forms of standard dysphagia therapy are more effective than others, such as swallowing therapy and physical therapy, compared to oral strengthening exercises.
- It is unclear whether oral feeding or nasogastric feeding increases the incidence of pneumonia. Regurgitation and aspiration are complications of enteral nutrition that can be avoided in part by the monitoring of infusion rate.
- There is conflicting evidence as to the effect of gastrostomy and nasogastric feeding tubes on mortality and pneumonia. Further research is required.
- Mode of nutritional intake in acute and rehabilitative recovery may be associated with severity of stroke, age, and functional outcome. Further research is required investigating the effects of mode of nutritional intake on dysphagia outcomes.
- Neuromuscular electrical stimulation may provide specific benefits in swallowing remediation which are not observed in general electrical stimulation.
- NMES combined with traditional dysphagia therapies are more effective in combination than either therapy alone.
- Pharyngeal electrical stimulation does not appear to significantly improve dysphagia or dysphagia symptoms.
- Variations of head positioning may be beneficial for improving swallowing function; however, further research is required.
- There is conflicting evidence regarding the effect of thermal application on factors of swallowing function and complications in patients with dysphagia.

- Additional research is needed to determine the effectiveness of various pharmaceutical medications at improving dysphagia related outcomes and reducing the incidence of aspiration and subsequent pneumonias.
- Transcranial direct current stimulation may improve dysphagia outcomes, however additional research trials with larger sample sizes are necessary to conclude a beneficial effect.
- Repetitive transcranial magnetic stimulation improves swallowing function and reduces penetration and aspiration among stroke patients with dysphagia, with potentially greater effects for higher frequencies compared to low frequencies.
- Individuals with dysphagia should feed themselves whenever possible. When not possible, low-risk feeding strategies are needed.

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15.1 Introduction

Dysphagia is defined as difficulty with swallowing and is a common complication of stroke. The incidence of dysphagia in acute stroke patients is reported to be approximately 55% (2013). Some of the variability is related to differences in the timing and method of swallowing assessment. 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 stay 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 associated with the 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.

15.1 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).

Oral Preparatory Phase. During this phase, food in the oral cavity is manipulated and masticated in preparation for swallowing. The back of the tongue controls the position of the food, preventing it from falling into the pharynx.

Oral Propulsive Phase. During the oral propulsive, the soft palate lifts, closing the nasopharynx; the tongue transfers the bolus of food posteriorly to the pharynx, triggering the pharyngeal swallow.

Pharyngeal Phase. During the pharyngeal phase, complex and coordinated movements of the tongue and pharyngeal structures propel the bolus from the pharynx into the esophagus. The closing of the vocal cords and the backward movement of the epiglottis prevents food or liquid from entering the trachea.

Esophageal Phase. During the esophageal phase of swallowing, coordinated contractions of the esophageal muscle move the bolus through the esophagus towards the stomach.

Conclusions Regarding Normal Swallowing

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

15.2 Pathophysiology of Dysphagia

Dysphagia post-stroke has long been attributed to pharyngeal 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 dysphasic 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, 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. Dysphasic patients were shown to have a significantly lower mean peak cough flow than either non-dysphasic patients or healthy controls (both $p<0.05$). 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 disease and provide potential methods of treatment.

Conclusions Regarding the Pathophysiology of Dysphagia Post-Stroke

The prevalence of dysphagia in the dysfunction of the pharyngeal phase of swallowing seems to be high. Functional disturbances may vary based on lesion location. Specific measures of pulmonary function seem to be inhibited by dysphagia.

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

Dysphagia is characterized by reduced coordination of pharyngeal 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 dysphasic symptomology.

15.3 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 patient 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 is initially 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 is carefully introduced. The full assessment is described elsewhere (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 15.3.1.

Table 15.3.1 Risk Factors for Aspiration Post-Stroke

- Brainstem Stroke
- Difficulty swallowing oral secretion
- 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 post-swallow residue and penetration-aspiration of the immediately occurring subsequent clearing swallow was examined. Results indicated that post-swallow vallecular residue, but not piriform 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 swallow safety for 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 issue (Molfenter & Steele, 2013).

Conclusions Regarding Aspiration Associated with Dysphagia

There is limited level 4 evidence suggesting that the presence of post-swallow vallecular residue 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.

15.3.1 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 utility of using VMBS studies. "Silent aspiration" is defined as "penetration of food below the level of the true vocal cords, without cough or any outward sign of difficulty" (Linden & Siebens, 1983). It is caused 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). However, two studies found the use of the Simplified Cough Test (SCT) to be a valuable tool in screening for silent aspiration in dysphasic 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 (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 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.

15.3.2 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 can accumulate to decrease quality of life and lead to social isolation (D. L. Cohen et al., 2016). As such, an early diagnosis of aspiration is important to avoid recurrent and alternative complications as well as improve recovery outcome. Several studies have estimated the incidence of aspiration and silent aspiration post-stroke using a combination of clinical and radiographic techniques.

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 post-stroke patients 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 determine 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, abnormal volitional cough and cough with 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.

15.4 Incidence of Dysphagia Post-Stroke

15.4.1 Incidence of Dysphagia in the Acute Phase of Stroke

The initial diagnosis of dysphagia is a critical step in treatment. Furthermore, the identification of indicators as they relate to an increase in the incidence of dysphagia will help to focus the effects of interventions for dysphagia management. There is a broad availability of assessments used to assess dysphagia after stroke.

The studies reviewed assessed swallowing status 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 dysphasic 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 institutionalisation. 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) Stroke region may also affect the incidence of dysphagia. A meta-analysis concluded that within the infratentorium, 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.

There is a wide range of the incidence of dysphagia following acute stroke and large variety of potential indicators. Further research is required.

15.4.2 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 the treatment of stroke patients (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 involved in 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).

The prognosis of dysphagia in acute stroke is complicated and associated with many variables. Further research is required to investigate additional indicators.

15.5 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 because of 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 15.5.1), as well as reduced levels 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 15.5.1 Factors More Likely to be Associated with 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

15.5.1 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 15.5.1.1 illustrates several criteria used to define aspiration pneumonia post-stroke.

Table 15.5.1 Criteria for Defining Pneumonia in Stroke

Author, Year Country PEDro Score	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.

15.5.2 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 increases a patients' risk of pneumonia. The incidence of pneumonia among dysphasic, bedridden patients who had suffered from a stroke for at least six months was 9/14 (63%). 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 is examined among a series of studies using odds ratios. The results are presented in Tables 15.5.2.1 and 15.5.2.2 and graphically in figures 15.5.2.1 and 15.5.2.2. In all cases the incidence of pneumonia was higher among patients with dysphagia and/or aspiration.

Table 15.5.2.1 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)**

Figure 15.5.2.1 Comparison of Pneumonia Frequency in Stroke Patients between Dysphagia and Non-Dysphagia

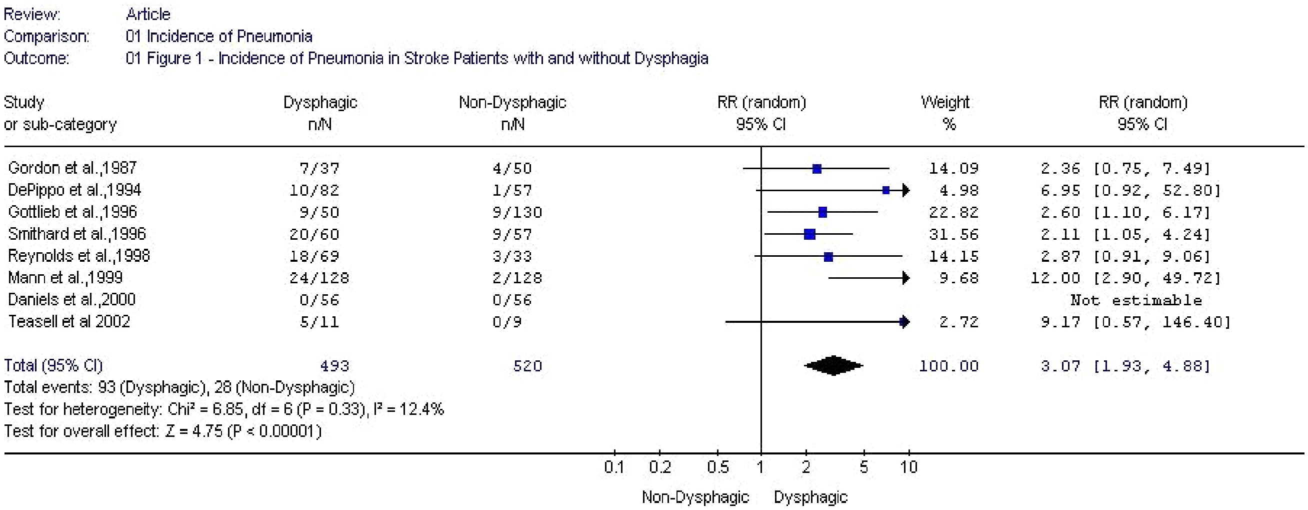
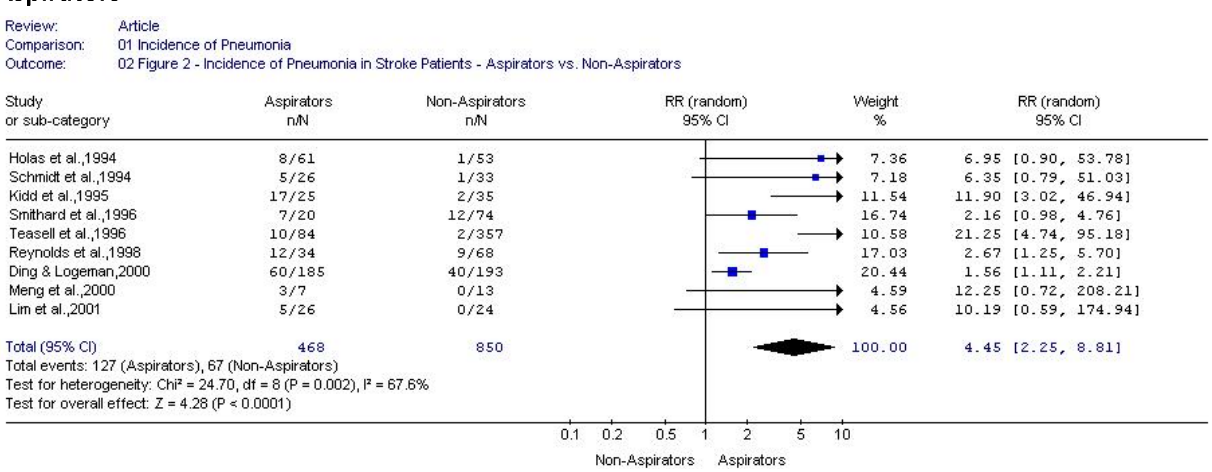


Table 15.5.2.2 Relationship Between Aspiration and Pneumonia

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)**

Figure 15.5.2.2 Comparison of Pneumonia Frequency in Stroke Patients between Aspirators and Non-Aspirators



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 intake of feed 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 from oral feeding. Earlier identification of the risks associated with feeding in dysphagia allows precautionary measures to be taken including dietary modification and teaching of compensatory swallowing techniques that may lessen the 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 pneumonia and dysphagia and subsequent aspiration in larger patient populations. However, there is sufficient evidence provided to suggest that both of these factors may increase the risk of pneumonia in post-stroke patients.

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.

15.5.3 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 problems, reported going to dental professionals less often after stroke) (B. Clayton, 2012). The oral cavity is host to organisms suspected to be responsible for aspiration 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 confounders 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 and denture usage before swallowing function assessment and cerebral atrophy, infarcted foci in the basal ganglia and Barthel Index <100 prior to admission after swallowing function 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 the decrease of aspiration pneumonia were also investigated. Reflux regimens, raising pH of gastric content over 2.5, reduced pre-sleep feeding and lifting the head off the bed were all beneficial to 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. The use of sensitive assessment tools for preventative measures requires increased attention to avoid the detrimental effects that pneumonia has on post-stroke dysphasic 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 of an increased risk of pneumonia.

Further research is required to determine the best tools for the prediction, identification and treatment of pneumonia.

15.5.4 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 15.5.4.1).

Table 15.5.4.1 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.

15.5.5 Prevention of Pneumonia Post-Stroke

In a massive study, 10,981 post-stroke patients were examined based on 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 15.5.5.1 summarizes several studies that evaluated various interventions for reducing pneumonia post stroke.

Table 15.5.5.1 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 dysphasic 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.

15.6 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 dysphasic complications. Individuals who fail the screen are maintained NPO until they can be assessed, preferably before the third day after the stroke. 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.

15.6.1 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.

15.6.1.1 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.

15.6.1.2 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).

15.6.1.3 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 complete assessment 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 dysphasic stroke patients 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, abnormal volitional cough, abnormal voice and abnormal 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 paste 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 tool 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.

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 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.

15.6.2 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 target specific functions or tasks, such as irregularities of speech (e.g., dysarthria, dysphonia), gag reflex or abnormal volitional cough, while others evaluate swallowing ability using a more comprehensive 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.

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 (Rosemary 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 utilised 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 which evaluation was impossible because of the mutism 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.

15.6.3 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 crichothyroid 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 suffered 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, needless dietary restrictions. Therefore, instrumental methods are frequently used to directly observe the swallowing mechanism.

Conclusions Regarding Alternative Non-Instrumental Dysphagia Screening and Assessment Techniques

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

15.7 Instrumental Methods Used in the Detection of Dysphagia/Aspiration

15.7.1 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 VMBS study examines the 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 placed in the sitting 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 15.7.1.1). The VMBS study is then followed by a chest x-ray to document any barium, which may have 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 reduced laryngeal closure or pharyngeal paresis. A VMBS study is recommended in those 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 15.7.1.1 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 during swallowing and 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 in sitting upright 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 quantity of 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 aspiration and/or penetration 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 aspiration and/or penetration 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.

Scintigraphy may be a valid tool for the detection of aspiration and penetration in dysphagia. Further research is required.

15.7.2 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 down the throat 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 15.7.2.1 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 suggests that a SLP-led FEES service significantly decreases the risk of pneumonia and improves discharge diet versus no FEES however, these benefits come at the cost of an increased length of stay in hospital and additional time on non-oral feeding. The authors suggest that all of these results are valuable in the treatment of post-stroke dysphagia. FEES in combination with a cough reflex test and clinical swallowing evaluation may focus the criteria for the induction of candidates for FEES 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 and a subsequent increase in length of stay. 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 changed 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, 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, abnormal 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 dysphasic 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 and length of stay in hospital.

Flexible endoscopic evaluation of swallowing may reduce the incidence of pneumonia and improve other important factors associated wtih dysphagia recovery; however, the evidence is limited and further research is required.

15.7.3 Pulse Oximetry

Pulse oximetry has also been suggested as an alternative to 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.

Among the information included above, there is conflicting evidence on the efficacy of pulse oximetry. Wang et al. (2005) reported no significant association between the reduction in oxygen saturation and aspiration, identified simultaneously by VFS, among 60 patients with dysphagia due to stroke and nasopharygeal cancer. Sellars et al. (1998) supported this finding, 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 in 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.

15.7.4 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 a proper 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 hemiplegic side, 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 VFSS 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%).

Further research is needed to determine whether ultrasonography or videofluoroscopy are valuable tools for determining swallowing function in dysphasic patients.

15.8 Interventions for Managing Dysphagia

15.8.1 Dietary Modifications

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, the wide variety that are used all include modified food and liquid textures. The standards for texture-modifications vary among countries. In one Canadian institution, special diets are based upon four distinct consistencies: thick fluids, pureed, minced and soft chopped. A dysphagia soft diet excludes all hard, small and stringy food particles (Bach et al., 1989). There are three consistencies of meat in the soft diet; soft chopped, minced and ground. A pureed diet has the consistency of pudding and is generally easier to swallow than a more regular diet (Veis & Logemann, 1985).

These diets are considered to be diets of necessity. Concerns have been raised over the nutritional quality of texture-modified foods and their relationship with malnutrition. Although there is evidence that their nutritional content may be inferior to regular textures, its contribution to the development of malnutrition is unclear as other factors such as stroke severity and feeding dependence may confound the nature of the relationship (Keller et al., 2012).

Over time, particularly in the early stages following stroke, changes to the diet can be made as the patient's dysphagia improves and the risk of aspiration lessens. Progression can be determined by clinical swallowing assessments unless the patient is a "silent aspirator", detectable only on VMBS study, in which case the clinical examination must be considered unreliable. A repeat VMBS study may be needed in these cases in order to guide management. 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. Many stroke patients, especially those with right hemispheric lesions, are very impulsive and may attempt to eat and swallow at too fast a rate. Finestone et al. (1998) documented a case in which a man, post-stroke, died following airway obstruction caused by a food bolus. Therefore close supervision with frequent cueing may be necessary in these cases (Milazzo et al., 1989). Alternatives to thin liquids such as jelled water or liquids may be required. There is some evidence that dietary modifications may reduce the incidence of aspiration pneumonia (Groher, 1987) although it has not been definitively established as to what effect the mode of feeding has on the rate of respiratory infection.

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. Severely dysphasic patients are often managed initially by enteral tube feedings and progress to the re-introduction of oral feeding, typically beginning with a pureed diet. Eventually patients are allowed thin liquids when it has been established that the patient can successfully swallow without aspirating.

Although thickened fluids may help to reduce the risk of aspiration and associated morbidity, Finestone et al. (2001) reported that patients restricted to thickened fluids not drink sufficient quantities to meet their fluid needs and are at risk for dehydration. Patients receiving dysphagia diets along with texture-modified solids received only 43% of their estimated fluid requirement over the first 21 days post-stroke, while in hospital. Although dietary modifications were not specifically addressed, Churchill et al. (2004) found that dysphasic patients had a higher risk of becoming dehydrated, defined as a peak blood urea nitrogen (BUN) ≥ 45. The odds ratio (OR) associated with dehydration was 4.2 (95% CI 2.1–8.3) among patients admitted for inpatient stroke rehabilitation, and was even higher for patients with aspiration, detected through videofluoroscopic examinations and presumed to be on a texture-modified diet (OR: 7.2; 95% CI 3.6-14.3), diuretic usage augmented the risk; an aspirating patient concurrently taking a diuretic for hypertension or management of congestive heart failure was 20 times more likely to experience dehydration (OR 19.8, 95% CI 3.0-211).

Dietary management is often directed by the results of VMBS studies. Studies examining the efficacy of fluid modifications are presented in Table 15.8.1.1.

Table 15.8.1.1 Summary of Studies Evaluating Dietary Modifications

Author, Year Study Design (PEDro Score) Sample Size	Intervention	Main Outcome(s) Result
Goulding & Bakheit (2000) RCT (6) N=46	E: Thickened fluids prepared using a viscometer (lesser viscosity) C: Thickened fluids prepared using subjective assessment (greater viscosity)	• Incidence of aspiration (-) • Thickened fluid intake (-)
Diniz et al. (2009) Cross-over RCT (6) N=61	E1: Liquid samples E2: Spoon-thick liquid samples	• Incidence of aspiration: E1 vs E2 (+) • Incidence of penetration: E2 (+)
Garon et al. (1997) RCT (5) N=20	E: Dysphagia diet (unlimited water between meals) C: Regular dysphagia diet (thickened fluids)	• Total fluid intake (-)
Groher (1987) RCT (3) N=56	E1: Soft mechanical diet + thickened liquids E2: Pureed foods + thin liquids	• Incidence of aspiration pneumonia (+)
McGrail et al. (2013) PCT N=30	E1: Thin liquid diet (Hospital group) E2: Thick liquid diet (Hospital group) C: Regular liquid intake (Community group)	• Fluid intake: C vs E1 (+); C vs. E2 (+); E1 vs. E2 (+)

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

Discussion

There is a general consensus among the results reported in Table 15.9.1.1 suggesting that thickened fluid improves risk of aspiration while reducing volume of fluid intake (Diniz et al., 2009; Garon et al., 1997). Findings by McGrail et al. (2013) were consistent with these conclusions; however, they also observed that regardless of the type of diet, fluid intake was below the minimum standard (of 1500mL). Daily intake of thickened fluids was significantly greater among post-stroke patients in an acute hospital versus a rehabilitation facility and younger age was significantly associated with an increase in thickened fluid consumption.

Park et al. (2013) found transit time of a bolus through the oral and pharyngeal phases of swallowing progressively increases with viscosity. In the oral phase this is not important, however, longer durations of pharyngeal swallow increase risk of aspiration. Impaired pharyngeal squeeze due to altered muscle tone among post-stroke dysphasic patients was shown to significantly contribute to this increased risk (Perlman et al., 2004). Furthermore, pharyngeal transit time differentiated between aspirators and non-aspirators suggesting that prolonged duration in this stage of swallow indicates that non-aspirating patients should be monitored and given a plan of action to avoid aspiration (D. H. Park et al., 2013). Finally, the authors state that it is possible to find the ideal bolus consistency of each stroke patient to maintain nutritional indices and avoid aspiration (D. H. Park et al., 2013). Goulding and Bakheit (2000) used a viscometer (versus subjective assessment) to prepare thickened fluids at a more appropriate consistency for individual post-stroke patients, leading to an improvement in dietary management and nutritional outcomes. Alternatively, two studies associated sour taste, low pH and/or cold temperature with longer transit times and clearance durations in the preliminary stages of swallow (Alves et al., 2013; Gatto et al., 2013). These factors should be studied further for their potential effect on management protocols.

Conclusions Regarding Dietary Modifications

There is level 1b and level 2 evidence supporting diets involving thickened liquids improving overall swallow safety and reducing incidence of aspiration pneumonia versus lower viscosity diets.

There is level 2 evidence suggesting that thin fluids may be associated with an increase of total fluid intake; however, it is also associated with an increase in aspiration pneumonia.

Thicker liquids enhance the safety of swallowing and reduce the incidence of pneumonia. Thinner fluid consumption may increase the total fluid intake and hydration; however, they also increase the incidence of aspiration pneumonia.

15.8.2 Swallowing Treatment Programs

Several studies have examined the effect of formal dysphagia therapy on a variety of outcomes (Table 15.8.2.1). Dysphagia therapy usually involves a combination of approaches, including exercises aimed at strengthening muscles, and improving movement and coordination. Possible modified swallowing strategiesmay 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 (http://www.mcw.edu/display/docid26360.htm), 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.

Table 15.8.2.1 Summary of Swallowing Treatment Programs

Author, Year Study Design (PEDro Score) Sample Size	Intervention	Main Outcome(s) Result
Carnaby et al. (2006) RCT (8) N=306	E1: Standard swallowing therapy (low-intensity intervention) E2: Standard swallowing therapy (high-intensity intervention and dietary prescription) C: Usual care	• Proportion of patients returned to a normal diet and recovered swallowing by 6mo: E2 vs C (+), E2 vs E1 (+)
Steele et al. (2016) RCT (6) N_{Start}=14 N_{End}=11	E1: Tongue-Pressure Profile Training group E2: Tongue-Pressure Strength and Accuracy Training group	• Tongue Strength Overall E1 & E2 (+) • Tongue Strength (-) • Penetration-Aspiration Scale (-)
Park et al. (2016a) RCT (6) N_{Start}=33 N_{End}=27	E: Expiratory Muscle Strengthening Group using a Device C: Placebo Device	• Liquid Penetration-Aspiration Scale (+) • Semisolid Penetration-Aspiration Scale (-) • Functional Oral Intake Scale (+)
Xia et al. (2016)	E: Acupuncture + Standard Swallowing	• Swallowing-Related Quality of Life (+)

RCT (6) N_{Start}=124 N_{End}=120	Therapy C: Standard Swallowing Therapy	• Dysphagia Outcome Severity Scale (+)
DePippo et al. (1994) RCT (5) N=115	E1: One formal dysphagia treatment session + choice of modified-texture diet E2: One formal dysphagia treatment session + prescribed texture-modified diet E3: Daily intervention by speech language pathologist + prescribed diet	• Occurrence of medical complications (-) • Death (-) • Dehydration (-) • Incidence of pneumonia: E2 vs E1 (+)
Bakhtiyari et al. (2015) RCT (5) N_{Start}=84 N_{End}=60	E1: Early Swallowing Therapy (3d) E2: Medium Swallowing Therapy (2wk) E3: Late Swallowing Therapy (1mo)	• Swallowing Recovery: E1 vs. E2+E3 (+) • Pneumonia Frequency: E1 vs. E2+E3 (+)
El-Tamawy et al. (2015) RCT (5) N_{Start}=30 N_{End}=30	E: Additional Physical Therapy + NMES C: No Additional Treatment	• Esophageal Sphincter Function (-) • Oral Transit Time (+) • Aspiration-Penetration Rate (+) • Hyoid Elevation (+) • Laryngeal Elevation (+)
Lin et al. (2003) PCT (Multi centred) N=49	E: Swallowing training C: No therapy	• Swallowing function (Incidence of coughing/choking; Volume/second swallowed; Volume per swallow): E vs C (+) • Neurological examination: E vs C (+) • Nutrition parameters (Mid-arm circumference and weight): E vs C (+)
Takahata et al. (2011) Case control N=219	E: Oral feeding intervention program C: No intervention program	• Proportion of patients with oral feeding tolerability: E vs C (+) • Incidence of chest infection: E vs C (+)

- Indicates non-statistically significant differences between treatment groups
+ Indicates statistically significant differences between treatment groups

Discussion

DePippo et al. (1994) conducted an RCT demonstrating no benefit of formal dysphagia therapy. However, the two-week treatment period may have been too short to result in a significant difference. Carnaby et al. (2006) found a trend towards statistical significance when examining the impact of two levels of dysphagia treatment programs (low and high intensity) on decreasing the need for a modified diet. Compared to usual care, patients who received instruction on compensatory swallowing strategies, swallowing exercises, and regular re-evaluation of dietary modifications were more likely to have returned to an unmodified diet at six months. Odderson et al. (1995) in a retrospective study found the introduction of a stroke program with dysphagia therapy improved dysphagia-related outcomes. Additionally, after recruiting patients from seven long-term care facilities, Lin et al. (2003) observed significant improvements on indicators of swallowing function, neurological examination and nutritional parameters among stroke patients with dysphagia. Takahata et al. (2011) restricted their inclusion to patients recovering from acute ICH and reported that patients who received early oral care and behavioural interventions could tolerate oral feeding earlier and had a lower incidence of chest infections than control patients.

In two high level RCTs Steele et al. (2016) and Park et al. (2016b) examined the effects of strength training on aspiration, Park et al. (2016b) did demonstrate that strength training could significantly improve liquid aspiration but not semi-solid. These results are consistent with Steele et al., (2016), which did not differentiate between liquid and semi-solid aspiration and saw no significant difference in aspiration between groups. Furthermore, although both groups received a training intervention their results show no significant effect of time for tongue strength, only the Tongue-Pressure Profile Training group saw a significant increase in overall tongue strength. However, there may be benefits to general physical therapy, as El-Tamawy et al. (2015) reported significant improvements in aspiration rates as well as oral transmit time.

One study demonstrated the potential benefit of acupuncture for the remediation of dysphagia (Xia et al., 2016), by combining acupuncture with standard swallowing therapy. Compared to patients in the swallowing therapy group only, the combination group saw a significant improvement in swallowing-related quality of life, and dysphagia severity. However, more research is needed to fully understand the potential benefits of acupuncture as a treatment for dysphagia.

Bakhtiyari et al. (2015) conducted an RCT which demonstrated that initiation of swallowing therapy earlier, rather than later, results in significant swallowing recovery compared to later intervention. The early swallowing training group experienced greater recovery than the medium and late swallowing therapy participants and also significantly reduced their incidence of pneumonia. Similarly, two prospective studies by, McCullough et al. (2012; 2013) investigated the suitability of the Mendelsohn maneuver as a rehabilitative exercise based on its ability to improve specific factors of swallowing physiology. Their results were consistent with previous findings, suggesting an improvement of hyoid movement, upper esophageal sphincter opening and the coordination of these structural movements together and with bolus flow after treatment with this technique. Nakamura and Fujishima (2013) found that ice massage of oropharyngeal structures significantly shortens swallowing latency, even in patients who were not able to elicit a swallow reflex prior to the massage. Furthermore, this effect was greater in patients with supranuclear versus nuclear lesions, suggesting a potential area for further research.

Conclusions Regarding Swallowing Treatment Programs

There is level 1b evidence supporting high intensity swallowing therapy with dietary prescription for better recovery of normal diet and swallowing ability in patients with dysphagia post-stroke compared to a lower intensity therapy or usual care.

Regarding formal dysphagia therapy, there is level 1a evidence that oral strength training may not be beneficial, while there is level 2 evidence that swallowing therapy and physical therapy are effective in reducing dysphagia.

There is level 2 evidence that acupuncture combined with physical therapy is more effective in treating dysphagia than physical therapy alone.

More research is needed to determine the benefit of high intensity swallowing therapy with dietary prescription at improving swallowing ability and return to a normal diet in patients with dysphagia post stroke.

Acupuncture combined with physical therapy can be an effective treatment for dysphagia, however more research is required to strengthen this treatment protocol.

Some forms of standard dysphagia therapy are more effective than others, such as swallowing therapy and physical therapy, compared to oral strengthening exercises.

15.8.3 Non-Oral Feedings

Non-oral or tube feeding in neurogenic aspiration has become a well-established rehabilitation practice. Anticipating the expected duration of the requirement for non-oral feeding however, is challenging. Recently, several factors associated with a quicker swallowing recovery were identified as being younger age (<75 yrs), independence prior to admission and an NIHSS score of ≤9 on day 10 post-stroke (Nakajima et al., 2012). In fact, NIHSS score at day 10 was more predictive of swallowing recovery than the same score at admission.

Although enteral feeding tubes have been shown to deliver adequate nutrition and hydration to stroke survivors, and can improve indicators of nutritional status, their use has been associated with some medical complications, most notably, aspiration pneumonia (Finestone et al., 1995; James et al., 1998). However, the association between enteral feeding and the subsequent development of pneumonia remains unclear as tube feeding has been identified as both protective and a risk factor for pneumonia. Table 15.8.3.1 presents a number of studies investigating factors associated with non-oral feeding.

Table 15.8.3.1 Summary of Studies Evaluating Non-Oral Feeding Interventions

Author, Year Study Design (PEDro Score) Sample Size	Intervention	Main Outcome(s) Result
Chen et al. (2015) PCT N_{Start}=210 N_{End}=206	E: Enteral nutrition (infusion rate monitored and adjusted) C: Enteral nutrition (without monitoring or adjusting the infusion rate)	• Higher incidence of regurgitation: C vs. E (+) • Higher incidence of aspiration: C vs. E (+)
Nakajoh et al. (2000) Prospective N=157	E1: Oral feeding with dysphagia E2: Nasogastric tube feeding with dysphagia E3: Nasogastric tube feeding in bedridden patients C: Oral feeding without dysphagia	• Higher incidence of pneumonia: E1/C vs. E2/E3 (+)
Mamun & Lim (2005) Prospective N=122	E1: Oral feeding with modified diet (including patients who refused nasogastric tube feeding) E2: Nasogastric tube feeding	• Higher incidence of aspiration pneumonia: E2 vs E1 (+)

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

Discussion

Dziewas et al. (2004) reported an extremely high rate of pneumonia (44%) among 100 acute stroke patients who were fed via nasogastric tube due to dysphagia. Most patients developed pneumonia on the second or third day following stroke (median of 2 days, range 0-9 days) and in some cases, while the feeding tube was being used only for gastric decompression, highlighting the fact that feeding tubes are not protective from colonized oral secretions. Factors most predictive of the development of pneumonia were initial decreased level of consciousness and facial palsy. More recently, the same authors (Dziewas et al., 2008) suggested that correctly-placed NG tubes do not interfere with swallowing physiology and do not increase the risk of aspiration, at least not in subjects with mild or moderately-disabling stroke. Therefore, it remains uncertain whether NG tubes pose a higher risk for the development of pneumonia following stroke and a physiological basis for a putative mechanism remains unknown. Most likely, other factors such as being bed bound, increased age and medical comorbidity confound the relationship.

Mamun & Lim (2005) reported a higher incidence of aspiration pneumonia and death among geriatric patients assigned to NG feeding. The results are confounded by the fact that NG fed patients were more cognitively and functionally impaired compared to those on oral feeding. However, in sub group analysis the rate of pneumonia was still higher among patients who accepted NG feeding compared with those who refused the treatment. Langdon et al. (2009) also reported an increased risk in the incidence of pneumonia associated with tube feeding. There was a significant time-to-event effect with 73% (22/30) respiratory infections in tube-fed survivors diagnosed on days two to four after stroke, and 76% (39/51) of infections in all tube-fed survivors occurring by day seven after stroke. The authors suggested that there may be a period of increased susceptibility to infections in the acute post-stroke period. The phenomenon, "stroke-induced immunodeficiency" has been coined to describe the condition in which there is an inhibition of cell-mediated immunity, which has been demonstrated in animal models.

In contrast to these findings, Nakajoh et al. (2000) reported that the incidence of pneumonia was 4.1 times greater among dysphasic stroke patients who were orally fed compared to those who received non-oral feedings suggesting that nasogastric tubes are protective for pneumonia. The authors also suggested that this protective effect might be limited to patients who are not bedridden. Contrary to all of the previous information presented here, Leder et al. (2008) reported that there were no significant differences in the incidence of aspiration among 1260 dysphasic patients with either a NG tube or no NG tube in place.

The findings by Chen et al. (2015) suggest that infusion rate during enteral nutrition should be monitored and adjusted to reduce the incidence of regurgitation and aspiration. Dubin et al. (2013) developed an objective score from variables available within the first day of stroke, among a sample of intracerebral hemorrhage and acute ischemic stroke patients, to predict their likelihood of receiving a percutaneous endoscopic gastrostomy (PEG) tube. A PEG score ≥3 for both groups was predictive of patients receiving a PEG tube.

Conclusions Regarding Non-Oral Feeding

There is conflicting level 2 evidence for whether oral feeding or nasogastric tube feeding increases the incidence of aspiration pneumonia among dysphasic patients.

There is level 2 evidence that a controlled infusion rate in enteral feeding based on the individual patient's gastric residual volume (GRV) may improve the incidence of regurgitation and aspiration versus no monitoring of the infusion rate.

It is unclear whether oral feeding or nasogastric feeding increases the incidence of pneumonia. Regurgitation and aspiration are complications of enteral nutrition that can be avoided in part by the monitoring of infusion rate.

15.8.4 Selection of Feeding Tubes

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). Table 15.8.4.1 presents the results of several studies evaluating nasogastric and percutaneously placed feeding tubes.

Table 15.8.4.1 Summary of Studies Evaluating Selection of Feeding Tubes

Author, Year Study Design (PEDro Score) Sample Size	Intervention	Main Outcome(s) Result
Dennis et al. (2005) RCT (7) N=321	E1: Gastrostomy tube E2: Nasogastric tube	• Incidence of pneumonia: (-) • Risk of death or poor outcome: E2 (+)
Beavan et al. (2010) RCT (7) N=104	E1: Adhesive tape secured nasogastric tube E2: Nasal loop secured nasogastric tube	• Proportion of prescribed feed delivered: E2 (+) • Frequency of nasogastric tube insertion: E2 (+) • Mortality (-) • Length of hospital stay (-) • Barthel Index (-)
Park et al. (1992) RCT (6) N=40	E1: Gastrostomy tube E2: Nasogastric tube	• Proportion of prescribed feed delivered: E1 (+) • Weight gain: E1 (+)
Norton et al. (1996) RCT (6) N=30	E1: Gastrostomy tube E2: Nasogastric tube	• Mortality: E1 (+) • Nutritional indices (-)
Kostadima et al. (2005) RCT (6) N=41	E1: Gastrostomy tube E2: Nasogastric tube	• Incidence of pneumonia: E1 (+) • Mortality (+)

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

Table 15.8.4.2 The Relative Risk of Death Associated with NG vs. Gastrostomy Feeding Among RCTs.

Study	Patients (N)	Length of follow-up	Relative Risk (95% CI) for Death (using NG as reference condition)
Norton et al. (1996)	Acute stroke (n=30)	6 weeks	5.47 (1.16, 18.05)
FOOD (2005)	Acute stroke (n=321)	6 months	0.98 (0.78, 1.23)
Kostadima et al. (2005)	ICU (n=41)	3 weeks	1.43 (0.47, 4.32)
Pooled estimate			1.07 (0.86, 1.33)

Discussion

1. Death or Poor Outcome

Three trials evaluated the risk of death associated with type of feeding tube (Dennis et al., 2005; Kostadima et al., 2005; Norton et al., 1996). The FOOD trial also assessed the risk of the combined outcome of death or poor outcome (defined as a modified Rankin scale score of 4-5) (Dennis et al., 2005). The results are difficult to pool and to interpret as the patient population and the length of follow-up varied between studies. The results are summarized in Table 15.9.4.2. While two studies reported an increased risk of death associated with NG feeding, neither the results from the individual studies, nor the pooled estimate was statistically significant. This finding suggests that the type of feeding tube used does not increase the risk of death.

2. Pneumonia

Two RCTs assessed the incidence of pneumonia associated with feeding tube type (Dennis et al., 2005; Kostadima et al., 2005). The data from the FOOD trial were not reported, however the authors noted that there was no difference in the proportion of patients who developed pneumonia between groups (gastrostomy vs. NG). Kostadima et al. (2005) reported that a significantly greater proportion of patients fed by a NG tube developed pneumonia within three weeks, compared to patients who had a gastrostomy tube placed immediately following admission to an ICU. The majority, but not all patients recruited for this study had suffered from a stroke and all were ventilator-dependent. Both groups of patients were similar in terms of baseline characteristics and medical management. The authors speculate that the reasons for the increase among patients with NG tubes may be due to: “disturbance of the pharyngoglottal refluxes that prevent aspiration, dysfunction of the upper and lower oesophageal sphincters and associated gastro-esoghageal reflux secondary to the presence of the tube and colonization of the stomach by bacteria that may subsequently migrate into the oropharynx and into the lower respiratory tract.” It is uncertain whether these results can be extrapolated to a non-ventilated population.

3. Alternative Outcomes

Park et al. (1992) and Norton et al. (1996) found that NG tubes result in a significantly lower delivery of prescribed feed than did gastrostomy tubes. Subsequently, patients who received gastro-enteric feeding experienced lower treatment failure, improvement on multiple nutritional indices including weight gain and had earlier discharge from hospital than patients fed with nasogastric tubes. Dennis et al. (2005) presented conflicting evidence on the safety of these two feeding techniques. In this study, gastrointestinal bleeds were significantly prevalent among NG tube fed patients, while the incidence of pressure sores was significantly increased among patients fed with PEG tubes. Beavan et al. (2010) found that among patients fed non-orally with a NG tube, a higher proportion of feed was delivered when the tube was secured with a nasal loop versus conventional means (adhesive tape). Consistent with this result, Anderson et al. (2004) also described the successful placement of NG tubes in stroke patients using the nasal loop technique to anchor tubes securely in place, preventing dislodgement and subsequent reinsertion. The authors stated that the secured nasal loops helped to avoid PEG tube insertion, giving patients more time to recover normal oral feeding or to avoid unnecessary insertion among patients with a poor prognosis.

Conclusions Regarding Selection of Feeding Tubes

There is level 1b evidence from a large, multicentre RCT that nasogastric tube feeding may decrease the incidence of death and poor functional outcome. The same study suggests that the type of tube feeding may not affect incidence of pneumonia however, there is level 1b evidence from a lower powered RCT suggesting a positive effect of gastro-enteric tubes.

There is conflicting level 1b evidence regarding the effect of gastrostomy tubes on mortality, proportion of prescribed feed delivered, and weight gained.

It is unclear which method of tube feeding (gastrostomy tube vs. nasogastric tube) is associated with a greater increase in the incidence of pneumonia.

There is conflicting evidence as to the effect of gastrostomy and nasogastric feeding tubes on mortality and pneumonia. Further research is required.

15.8.5 Mode of Nutritional Intake

Swallowing difficulties are among the most common complications in acute stroke. Within three months, 75% of severely dysphasic individuals are unable to maintain oral intake (Nakajima et al., 2012) and by six months 10% cannot eat orally (Nakajima et al., 2012; Smithard et al., 1996). The development of proper nutrition in the acute phase of stroke, and the ability of patients and their caregivers to maintain this nutrition through the chronic stage continues to be an important factor dictating quality of life (Nakajima et al., 2014). The studies discussed in this chapter (Table 15.8.5.1) evaluate the effectiveness of different techniques involved in early nutrition on recovery outcome and the transition between acute to chronic stage rehabilitation among post-stroke dysphasic patients.

Table 15.8.5.1 Summary of Mode of Nutritional Intake

Author, Year Study Design (PEDro Score) Sample Size	Intervention	Main Outcome(s) Result
Nakajima et al. (2014) Case Control N_{Start}=2913 N_{End}=2913	E1: Oral intake E2: Tube feeding	• NIHSS: E1 (+) • Frequency of small vessel occlusion: E2 (+) • Frequency of cardioembolism: E1 (+)
Maeshima et al. (2013) Case Series N_{Start}=334 N_{End}=334	E1: Oral intake E2: Tube feeding	• FIM gain at acute care hospital: E1 (+) • Age: E1 (+)

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

Discussion

Nakajima et al. (2014) found an upward trend in the proportion of patients who achieved oral intake within three months of stroke over the course of the nine year study period, independent of potential cofounders. The authors explained that this outcome may have been resultant of an overall decrease in the severities of stroke due to an increase in general knowledge about stroke onset and identification, evident from decreasing NIHSS scores on day one and day 10 post-stroke. The development of new swallowing rehabilitation techniques may also have had an effect. In another study evaluating method of nutrition between acute and rehabilitation stages of recovery post-stroke, Maeshima et al. (2013) concluded that younger age and gain on the Functional Independence Measure during acute care were indicative of oral intake at discharge from a rehabilitation hospital. Further research is necessary to investigate the association between modes of nutritional intake and stroke outcome in hopes that this information will aid in the development of more efficacious and/or novel techniques of rehabilitation.

Conclusions Regarding Mode of Nutritional Intake

There is level 3 evidence that oral intake versus tube feeding may be related to stroke severity.

There is level 4 evidence that oral intake versus tube feeding at discharge may be associated with lower age and improved functional independence during acute care.

Mode of nutritional intake in acute and rehabilitative recovery may be associated with severity of stroke, age, and functional outcome. Further research is required investigating the effects of mode of nutritional intake on dysphagia outcomes.

15.8.6 Electrical Stimulation

In the past, dysphagia therapy has focussed on behavioural compensatory strategies. These include changes to dietary content and texture as well as altered posture and physical manoeuvers. 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).

Electrical stimulation 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). Although electrical stimulation is widely used clinically in the United States, there is a lack of evidence supporting its use. A recent meta-analysis including the results from seven trials reported a large effect size associated with the treatment (Carnaby-Mann & Crary, 2007). However, the participants in the individual trials were dysphasic due to a variety of conditions, including stroke. The results from the trials included in the present review suggest that the effectiveness of electrical stimulation has not yet been established when compared to traditional swallowing therapy (TDT). However, among the available literature, surface e-stim has been shown to be a safe and effective treatment for acute to chronic post-stroke dysphagia (Rofes et al., 2013).

Furthermore, a number of the studies included in this section involve the use of a combination of electrical stimulation and some form of traditional dysphagia therapy. These traditional therapies can combine the use of multiple clinical techniques including thermal-tactical stimulation, lingual-strengthening exercises, laryngeal adduction-elevation exercises, effortful swallow maneuver, Mendelsohn maneuver, Masako maneuver and Shaker exercises (Kushner et al., 2013; K. W. Lee et al., 2014). These methods are used alongside on another to enhance the clinical effects of TDT alone. Especially in cases of severe dysphagia where TDT may have limited success, prolonged treatment and short lasting effects (Sun et al., 2013).

Table 15.9.6.1 Summary of Studies Evaluating Electrical Stimulation for Dysphagia

Author, Year Study Design (PEDro Score) Sample Size	Intervention	Main Outcome(s) Result
Jayasekeran et al. (2010) RCT (8) N=50	E: Pharyngeal electrical stimulation C: Sham stimulation	• Number of episodes of aspiration: E (+) • Dysphagia severity rating scale: E (+) • Time spent in hospital: E (+)
Terre et al. (2015) RCT (8) N_{Start}=20 N_{End}=20	E: NMES + conventional swallowing therapy C: Sham electrical stimulation + conventional swallowing therapy	• Functional oral intake scale after treatment: post E (+); 3mo E (-) • Bolus viscosity at appearance of aspiration: E (+)
Nam et al. (2013) RCT (7)	E1: Hyolaryngeal electrical stimulation on the suprahyoid muscle	• Maximal anterior hyoid excursion distance (-) • Maximal anterior velocity of the hyoid

N_{Start}=66 N_{End}=50	E2: Hyolaryngeal electrical stimulation on the suprahyoid and infrahyoid muscles	excursion (-) • Maximal superior laryngeal elevation distance (-)
Huang et al. (2014) RCT (7) N_{Start}=29 N_{End}=29	E1: NMES E2: NMES + traditional swallowing therapy (TST) C: TST	• Functional dysphagia scale: E1 vs. E2/C • 8-point penetration-aspiration scale (-) • Functional oral intake scale (-)
Vasant et al. (2016) RCT (7) N_{Start}=36 N_{End}=33	E: Pharyngeal Electrical Stimulation C: Sham Stimulation	• Dysphagia Severity Rating: 2wk(-), 3mo (-) • Penetration-Aspiration Scale: 2wk(-), 3mo(-)
Bath et al. (2016) RCT (7) N_{Start}=162 N_{End}=121	E: Pharyngeal Electrical Stimulation C: Sham Stimulation	• Penetration-Aspiration Scale (-) • Clinical Swallowing (-)
Byeon & Koh (2016b) RCT (6) N_{Start}=45 N_{End}=45	E1: NMES E2: Thermal Tactile Oral Stimulation	• Videofluoroscopic (-)
Permsirivanich et al. (2009) RCT (6) N=23	E: NMES C: Rehabilitation swallowing therapy	• Requirement of non-oral feeding (-) • Functional oral intake scale: E (+)
Zhang et al. (2016) RCT (5) N_{Start}=90 N_{End}=82	E1: Sensory NMES + Swallowing training E2: Motor NMES + Swallowing training C: Swallowing training	• Standardized Swallowing Assessment: E1 vs. E2+C (+) • Functional Oral Intake Scale: E1 vs. E2+C (+) • Swallowing-Related Quality of Life: E1 vs. E2+C (+)
El-Tamawy et al. (2015) RCT (5) N_{Start}=30 N_{End}=30	E: Additional Physical Therapy + NMES C: No Additional Treatment	• Esophageal Sphincter Function (-) • Oral Transit Time (+) • Aspiration-Penetration Rate (+) • Hyoid Elevation (+) • Laryngeal Elevation (+)
Power et al. (2006) RCT (4) N=16	E: Electrical stimulation to the anterior faucial pillar C: Sham stimulation	• Speed of laryngeal elevation (-) • Pharyngeal transit time (-) • Aspiration severity (-)
Xia et al. (2011) RCT (4) N=120	E1: Electrical stimulation + VitalStim therapy E2: VitalStim therapy + conventional swallowing therapy C: Conventional swallowing therapy	• Standardized swallowing assessment: E2 vs. E1/C, E2 (+)
Lee et al. (2014) RCT (4) N_{Start}=57 N_{End}=57	E: NMES + traditional dysphagia therapy C: Traditional dysphagia therapy	• Functional oral intake scale: E (+)
Bülow et al. (2008) RCT (3) (multicenter) N=25	E: NMES C: Traditional swallowing therapy	• Videoradiographic swallowing evaluation (-) • Nutritional status (-) • Oral motor function test (-) • Visual analog scale (-)
Lim et al. (2009) RCT (3) N=36	E: Thermal- tactile stimulation + NMES C: Thermal-tactile stimulation	• Swallow function scoring system: E (+) • Penetration-aspiration scale: E (+) • Pharyngeal transit time: E (+)

Freed et al. (2001) PCT N=99	E1: Thermal-tactile stimulation E2: Electrical stimulation	• Swallowing score (aspiration scale): E2 (+)
Kushner et al. (2013) PCT N_{Start}=92 N_{End}=92	E: NMES + traditional dysphagia therapy with progressive resistance training C: Traditional dysphagia therapy with progressive resistance training	• Functional oral intake scale: E (+) • Number of patients with minimal/no swallowing restrictions: E (+)

+ Indicates statistically significant differences between treatment groups
- Indicates non-statistically significant differences between treatment groups

Discussion

Two of the studies included in Table 15.9.6.1 compare the usefulness of thermal-tactile stimulation (TTS) and electrical stimulation. TTS involves the application of a cold stimulus to the anterior faucial pillars prior to the patient swallowing and results in success rates ranging from 0 to 83% (J.C. Rosenbek et al., 1991). However, these results were observed with samples comprised of patients with low dysphagia severity and as such may be subject to confounding. Logemann (1983) suggested that this technique involves an increase of oral awareness due to the cold stimulation alerting upper neurological pathways, priming the patient for the instigation of a rapid pharyngeal swallow. A variation of NMES is also used. VitalStim therapy is a specific type of NMES. This technique requires dysphasic patients to complete a sequence of protocols including perception of swallowing action, subsequent initial automatic swallowing and entirely automatic swallowing (Kiger et al., 2006).

In this review, treatment interventions were varied: electrical stimulation vs. sham stimulation, electrical stimulation vs. conventional therapy and electrical stimulation combined with conventional therapy vs. conventional therapy vs. electrical stimulation only. In the largest study, Xia et al. (2011) found that the combination of two co-interventions [VitalStim neuromuscular electrical stimulation (NMES) + conventional therapy] improved swallowing function when compared to either of the two interventions administered in isolation; this conclusion is also supported by two RCTs by El-Tamawy et al. (2015) and Zhang et al. (2016). No difference was found between the individual intervention groups in Xia et al. (2011), indicating that the combination of these methods is most beneficial for the improvement of dysphagia. Three potential mechanisms were presented to explain the observed results. Successive rehabilitative therapy and NMES may have restored cerebral function by stimulating previously unused synapses to transmit nerve impulses which may subsequently instigate muscle contraction, delaying or averting disuse atrophy and hastening increased swallowing muscle function. Additionally, the authors noted a significant correlation between the standardized swallowing assessment (SSA) and VFSS used as outcome measures in this study, suggesting that SSA may potentially be used in clinical practice to evaluate swallowing function as an alternative to videofluoroscopy. However, it should be noted that one higher level RCT study found no effect of NMES on videofluoroscopy between groups (Byeon & Koh, 2016b).

Concordantly, NMES used with traditional dysphagia therapy (TDT) as an early (>10 days) intervention among acute/subacute ischemic stroke patients with moderate to severe dysphagia significantly improved functional oral intake when compared to traditional therapy alone (K. W. Lee et al., 2014). The authors suggest NMES combined with traditional dysphagia therapy should be initiated as early as possible after stroke onset to achieve the most beneficial outcome. Additionally, Kushner et al. (2013) investigated the efficacy of NMES and TDT including progressive resistance training (PRT) versus TDT/PRT alone among patients suffering from an acute ischemic or hemorrhagic hemisphere and brainstem stroke with severe feeding tube-dependent dysphagia. Results indicated that co-intervention significantly improves functional oral intake and feeding tube dependency among patients in this population. Previous research suggests that neural repair post-stroke presents a window of opportunity lasting up to three months during which the majority of functional recovery takes place (Jorgensen et al., 1999). The combination of NMES and TDT/PRT should be used during this period of time to maximize plasticity and recovery. It is thought that these interventions concurrently stimulate type 1 (NMES) and 2 (TDT/PRT) oropharyngeal muscle fibers increasing feedback to cortical/subcortical swallowing areas, decreasing disuse atrophy and strengthening these neural pathways (Kushner et al., 2013).

Lim et al. (2009) found that the combination of NMES with tactile-thermal stimulation (TTS), part of the traditional dysphagia therapy from Lee et al. (2014) and Kushner et al. (2013) resulted in an improvement of swallowing function when compared to the independent application of TTS in stroke patients with dysphagia. Freed et al. (2001) went further to show that electrical stimulation significantly improved swallowing scores versus TTS, suggesting that NMES alone may have been responsible for the main combined effect of these therapies witnessed by Lim et al. (2009).

In contrast to the positive effects of NMES, two high level RCTs by Bath et al. (2016) and Vasant et al. (2016) did not show any significant improvement on dysphagia symptoms with treatment of pharyngeal electrical stimulation. Neither study found that patients improved on dysphagia severity or aspiration, suggesting that there are specific benefits related to the NMES protocol compared to pharyngeal electrical stimulation.

From this information, electrical stimulation seems to have a positive effect in dysphagia therapy. However, two meta-analyses evaluating thirteen studies present conflicting evidence. Stroke patients with various etiologies were compared to determine the effect of NMES versus traditional swallowing therapy on swallowing function. Overall improvements were noted on the swallowing function scale however, when analysis was limited to stroke, the effectiveness of both therapies were comparable (Tan et al., 2013). Carnaby-Mann and Crary (2007) saw a slightly significant improvement of swallowing function among adult dysphasic patients of multiple etiologies after NMES treatment versus no NMES. However, this conclusion was based on a small number of studies with low methodological quality.

There is evidently a wide range of conflicting studies reporting the effectiveness of NMES for the treatment of dysphagia. The amount of controversial evidence suggests the need for more large scale, high quality studies investigating the association of this technique on swallowing function since the amount of evidence signifying a positive outcome from studies with low power and methodological quality is substantial.

Conclusions Regarding Transcutaneous Electrical Stimulation

There is conflicting level 1a, level 1b, and level 2 evidence that transcutaneous pharyngeal electrical stimulation may not improve swallowing function when compared to traditional swallowing therapy.

There is level 2 evidence from multiple RCTs that NMES is effective in treating dysphagia, more so when combined with traditional therapies.

There is level 2 evidence that electrical stimulation may improve swallowing function and the incidence and severity of penetration-aspiration when compared to thermal-tactile stimulation.

Neuromuscular electrical stimulation may provide specific benefits in swallowing remediation which are not observed in general electrical stimulation.

NMES combined with traditional dysphagia therapies are more effective in combination than either therapy alone.

Pharyngeal electrical stimulation does not appear to significantly improve dysphagia or dysphagia symptoms.

15.8.7 Head Positioning

Several factors of swallowing function measured by videofluoroscopy were significantly related to an inefficiency of swallowing in the chin down position. The authors concluded that videofluoroscopic measurement should be used to differentiate between patients who are appropriate for treatment with this technique (Terre & Mearin, 2012). Overall, 55% of patients (with stroke or traumatic brain injury) avoided aspiration in the chin down position (Terre & Mearin, 2012). While head rotation had no effect on swallowing among healthy controls, this intervention was shown to improve swallowing function in a small sample of stroke patients with unilateral oropharyngeal dysphagia (J.A. Logemann et al., 1989).

Conclusions Regarding Head Positioning

Variations of head positioning may be beneficial for improving swallowing function; however, further research is required.

15.8.8 Thermal Application

Several RCTs investigated the effect of thermal application on dysphagia and swallowing function. A summary of these studies is presented below in Table 15.8.8.1

Table 15.8.8.1 Summary of Studies Evaluating the Effect of Thermal Application on Dysphagia Outcomes

Author, Year Study Design (PEDro Score) Sample Size	Intervention	Main Outcome(s) Result
Rosenbek et al. (1991) RCT Cross-over (6) N=7	E: Thermal application C: No thermal application	• Incidence of aspiration (-) • Incidence of penetration (-) • Incidence of residue (-)
Nakamura & Fujishima (2013) RCT cross-over (6) N=24	E: Ice massage C: No Ice massage	Patients able to initiate the swallow reflex: • Latency (all): E vs C (+) • Latency (supranuclear lesions): E vs C (+) • Latency (nuclear lesions) (-) Patients unable to initiate the swallow reflex: • Number of swallows: E vs C (+) • Number of swallows (supranuclear lesions): E vs C (+) • Number of swallows (nuclear lesions) (-) • Latency (all): C vs E (+) • Latency (supranuclear lesions): C vs E (+) • Latency (nuclear lesions) (-)
Byeon & Koh (2016b) RCT (6) N_{Start}=45 N_{End}=45	E1: NMES E2: Thermal Tactile Oral Stimulation	• Videofluoroscopic (-)

Rosenbek et al. (1998) RCT (5) N=45	E1: 150 trials/wk of tactile-thermal stimulation E2: 300 trials/wk E3: 450 trials/wk E4: 600 trials/wk	• Duration of stage transition (3ml liquid): week 1 (-), week 2 (-) • Duration of stage transition (10ml liquid): week 1 (-), week 2 (-) • Penetration/aspiration (3ml liquid): week 1 (+), week 2 (+) • Penetration/aspiration (10ml liquid): week 1 (-), week 2 (-)

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

Discussion
Conflicting evidence reporting the efficacy of thermal application on the prevention of penetration-aspiration was presented. No benefit of cold stimulus on swallowing function was shown (Byeon & Koh, 2016a; J.C. Rosenbek et al., 1991; John C. Rosenbek et al., 1998). However, ice massage applied before dry swallow improved factors of swallowing efficiency (Nakamura & Fujishima, 2013). The effect size was magnified for patients with supranuclear lesions, suggesting a connection between this technique and the supranuclear tract and/or normal nucleus and subnuclear tract.

Conclusions Regarding Thermal Application

There is conflicting level 1b and level 2 evidence regarding the effect of intensity and presence of thermal application on the incidence of aspiration and penetration.

There is level 1b evidence that swallowing efficiency is improved, specifically among patients with supranuclear lesions after dry swallow preceded by ice massage of the oral cavity.

There is conflicting evidence regarding the effect of thermal application on factors of swallowing function and complications in patients with dysphagia.

15.8.9 Pharmacotherapy
Several RCTs investigated the effect of pharmacotherapy on dysphagia and swallowing function. A summary of these studies is presented below in Table 15.8.9.1.

Table 15.8.9.1 Summary of Studies Evaluating the Effects of Pharmacotherapy on Dysphagia

Author, Year Study Design (PEDro Score) Sample Size	Intervention	Main Outcome(s) Result
Perez et al. (1998) RCT (7) N=17	E: Nifedipine + speech therapy C: Placebo + speech therapy	• Mean pharyngeal transit time: E vs C (+) • Swallowing delay: E vs C (+) • Pharyngeal response (-)
Abe et al. (2013) RCT (4) N_{Start}=21 N_{End}=20	E: Aspirin + cilostazol C: Aspirin	• Latent time of swallowing reflex (-)
Arai et al. (2003) RCT (letter to editor) N=51	E1: Cabergoline E2: Amantadine E3: Imidapril (hypertensive patients) C: No active treatment	• Incidence of aspiration pneumonia: E1/E2/E3 vs. C (+)

Osawa et al. (2013a) Case Series N=189	E: Cilostazol C: No cilostazol	• Incidence of aspiration pneumonia: E vs C (+)

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

Discussion

Nifedipine was found to improve swallowing delay and pharyngeal transit time when compared to placebo (Perez et al., 1998). When aspirin was combined with cilostazol, the time of swallowing reflex was not found to be significantly different than when compared to aspirin alone (Abe et al., 2013). However, when cilostazol was compared to placebo in a large case series, the results demonstrated a significantly lower incidence of aspiration pneumonia (Osawa et al., 2013b). A reduction in aspiration pneumonia was also associated with the use of Cabergoline, Amantadine, and Imidapril compared to an absence of active treatment (Arai et al., 2003). Despite the positive findings observed, all studies were low powered and suffered from a low methodological quality. Appropriate placebo groups should also be considered in future research investigating the effects of pharmaceutical drugs on dysphagia outcomes.

Conclusions Regarding Pharmacotherapy on Dysphagia Outcomes

There is level 1b evidence that nifedipine may be associated with improved swallowing function versus placebo. Level 2 evidence indicates that cilostazol prescribed with aspirin may not have an effect on swallowing function compared to aspirin alone.

There is level 2 and level 4 evidence that treatment of dysphagia with cabergoline, amantadine, imidapril, or cilostazol may reduce the incidence of aspiration and subsequent pneumonia when compared to no treatment.

Additional research is needed to determine the effectiveness of various pharmaceutical medications at improving dysphagia related outcomes and reducing the incidence of aspiration and subsequent pneumonias.

15.8.10 Transcranial Direct Current Stimulation (tDCS)

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. This method of neurostimulation uses a constant low current applied peripherally via electrodes to stimulate the affected brain area. Thus far, only three RCTs investigated the effect of tDCS on dysphagia and swallowing function. A summary of these studies is presented below in Table 11.8.10.1.

Table 15.8.10.1 Summary of Studies Evaluating Transcranial Direct Current Stimulation (tDCS)

Author, Year Study Design (PEDro Score) Sample Size	Intervention	Main Outcome(s) Result
Yang et al. (2012) RCT (8) N=16	E: Transcranial direct current stimulation C: Sham stimulation	• Functional dysphagia scale: E vs C (+) • Total transit time (-)

Kumar et al. (2011) RCT (7) N=14	E: Transcranial direct current stimulation C: Sham stimulation	• Dysphagia Outcome and Severity scale: E vs C (+)
Shigematsu et al. (2013) RCT (7) N_{Start}=20 N_{End}=20	E: Transcranial direct current stimulation C: Sham stimulation	• Dysphagia Outcome and Severity scale: E vs C (+)

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

Discussion

All three studies presented in Table 15.10.1 found improvements on dysphagia outcomes following tDCS (Kumar et al., 2011; Shigematsu et al., 2013; Yang et al., 2012). Despite these improvements, future studies should consider larger sample sizes when investigating the effects of tDCS on dysphagia outcomes.

Conclusions Regarding Transcranial Direct Current Stimulation

There is level 1a evidence suggesting that transcranial direct current stimulation (tDCS) may improve functional severity of dysphagia when compared to sham stimulation.

Transcranial direct current stimulation may improve dysphagia outcomes; however, additional research trials with larger sample sizes are necessary to conclude a beneficial effect.

15.8.11 Repetitive Transcranial Magnetic Stimulation (rTMS)

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. A total of seven RCTs investigated the effect of rTMS on dysphagia and swallowing function. A summary of these studies is presented below in Table 15.8.11.1.

Table 15.8.11.1 Summary of Studies Evaluating Repetitive Transcranial Magnetic Stimulation (rTMS)

Author, Year Study Design (PEDro Score) Sample Size	Intervention	Main Outcome(s) Result
Du et al. (2016) RCT (9) N_{Start}=40 N_{End}=38	E1: 3Hz rTMS E2: 1Hz rTMS C: Sham Stimulation	• Standardized Swallowing Assessment: E1+E2 vs. C (+)
Park et al. (2013) RCT (8) N_{Start}=18 N_{End}=18	E: Repetitive transcranial magnetic stimulation C: Sham stimulation	• Penetration-Aspiration scale: E vs C (+) • Videofluoroscopic dysphagia scale: E vs C (+)
Khedr et al. (2009) RCT (6) N=26	E: Repetitive transcranial magnetic stimulation C: Sham stimulation	• Dysphagic Outcome and Severity Scale: E vs C (+)
Khedr & Abo-Elfetoh (2010) RCT (6)	E: Repetitive transcranial magnetic stimulation	• Dysphagia grading scale: E vs C (+)

N=22	C: Sham stimulation	
Michou et al. (2014) RCT (6) N_{Start}=18 N_{End}=18	E1: Repetitive transcranial magnetic stimulation E2: Paired associative stimulation E3: Pharyngeal electrical stimulation C: Sham stimulation	• Cumulative Penetration-Aspiration scale: E3 vs. C (+); E2 vs. C (+); E1 vs. C (-); E1/E2/E3 vs. C (+) • Pharyngeal response time: E1/E2/E3 vs. C (+)
Momosaki et al. (2014) RCT (6) N_{Start}=20 N_{End}=20	E: Functional magnetic stimulation C: Sham stimulation	• Interswallow interval (-) • Speed of swallow: E vs C (+) • Capacity of swallow: E vs C (+)

+ Indicates statistically significant differences between treatment groups

- Indicates no statistically significant differences between treatment groups

Discussion

As with tDCS, the use of rTMS was demonstrated to have a positive effect on dysphagia outcomes, with higher frequency rTMS being more effective than lower frequency rTMS (Du et al., 2016). There is however some conflicting evidence suggesting that the incidence of penetration-aspiration and inter-swallow interval are not improved by this technique (Michou et al., 2014; Momosaki et al., 2014). Although rTMS was found to improve dysphagia outcomes, more studies are encouraged to determine if this intervention is efficacious in only certain stages of stroke and severity. Furthermore, evidence is needed to determine if the effect is maintained at various time intervals following the intervention.

Conclusions Regarding Repetitive Transcranial Magnetic Stimulation

There is level 1a evidence that repetitive transcranial magnetic stimulation (rTMS) improves penetration and aspiration, swallowing function and functional disability compared to sham stimulation.

Repetitive transcranial magnetic stimulation improves swallowing function and reduces penetration and aspiration among stroke patients with dysphagia, with potentially greater effects for higher frequencies compared to low frequencies.

15.9 Recommendations for Management of Dysphagia Post-Stroke

As mentioned previously, the VMBS study is still considered the "gold standard" in the diagnosis of aspiration. Those patients who have difficulty with high volumes of thin liquids are considered to be at mild to moderate risk of aspiration. In these cases oral feedings are regarded as appropriate. Before deciding if a patient is a candidate for oral feeding, factors such as the patient's respiratory status, the effectiveness of airway clearance along with the type and amount of aspirate must first be considered (Bach et al., 1989). Aspirating more than 10% of the test bolus is generally considered an indication for non-oral (i.e. nasogastric, gastrostomy, jejunostomy tube) feedings; however, the actual risks present with oral feedings for this group of patients have not been fully established. Determining whether the patient actually aspirates more or less than 10% of the test bolus is, as mentioned previously, an inexact science.

15.9.1 Management Strategies for Dysphagia

The Heart and Stroke Foundation Dysphagia Guidelines noted that, "a well-coordinated care plan can minimize the development of dysphasic complications, reduce length of hospital stay in acute-care facilities and expedite access to specialized rehabilitation centers," (Heart and Stroke Foundation of Ontario, 2002).

Dysphagia management has the following goals:

- Meeting the nutrition and hydration requirements of the stroke survivor.
- Preventing aspiration-related complications.
- Maintaining and promoting swallowing function as much as possible.

Dysphagia management strategies include the following:

- Modifying food and fluid textures to increase safety of oral intake.
- Using low-risk feeding practices and compensatory strategies to prevent complications such as aspiration and choking.
- Monitoring oral intake to prevent dehydration.
- Supplementing the diet to maintain adequate nutrition.
- Using enteral feeding for individuals who are unable to swallow.
- Implementing swallow therapy to rehabilitate specific physiological swallowing impairments.
- Implementing oral care regimens, and possible referral to other healthcare professionals.

A speech-language pathologist should regularly monitor the status of individuals with dysphagia to ensure that the management strategies employed remain appropriate," (Heart and Stroke Foundation of Ontario, 2002).

15.9.1.1 Oral Care as a Management Strategy for Dysphagia

An important management strategy for dysphagia is good oral hygiene, however, often times oral care guidelines are not provided to patients prior to discharge. Literature shows that health care professionals do not consider oral care to be of high priority, and many do not have adequate knowledge of proper practices or do not enjoy performing the oral hygiene care (Kelly et al., 2010). In the absence of literature that pertains to oral care, Kelly et al. (2010) synthesized the existing evidence and suggested the following recommendations:

- Assessment of oral hygiene should be completed using a standardized screening tool and following best practice guidelines.
- Assistance for oral provisions should be done so on an individualized basis.
- Patients should be provided with education and information to enable them to meet their oral hygiene needs, be able to select and use appropriate oral hygiene equipment, and recognize and manage difficulty of swallowing.

Recommendations for oral care management strategies in a dysphagia post-stroke are twofold: to control dental plaque/patient oral hygiene and to improve knowledge, education and attitudes of healthcare staff (Kelly et al., 2010). A review article by Brady et al., (2006) evaluated the effects of a staff-led oral health care intervention in improving the oral health of patients. The results illustrated that after staff completed proper oral care training, they had significantly better attitudes towards oral care and higher knowledge scores ($p<0.05$) (Brady et al., 2006).

There is a distinct lack of evidence to support the need and effectiveness for standardized oral care for post-stroke populations. Including a wider multidisciplinary healthcare team to include other professionals such as OT, SLP, physiotherapists, dieticians, may help to improve recovery outcomes (Brady et al., 2006). Furthermore, increasing educational training for staff would benefit client care and evidence based practices (Kwok et al., 2015).

15.9.2 Best Practice Guidelines for Managing Dysphagia

Best practice guidelines for managing dysphagia were developed by a consensus committee sponsored by the Heart and Stroke Foundation of Ontario. These are summarized in Table 15.9.2.1.

Table 15.9.2.1 Canadian Stroke Best Practice Recommendations (Hebert et al., 2016)

- Patients should be screened for swallowing deficits as soon as they are alert and ready for trialing oral intake (e.g. medications, food, liquid) using a valid screening tool by an expert in dysphagia, ideally a speech-language pathologist (SLP); if an SLP is not available this should be done by another appropriately trained professional
- Abnormal results from the initial or ongoing swallowing screens should prompt a referral to a speech-language pathologist, occupational therapist, dietitian or other trained dysphagia clinician for more detailed bedside swallowing assessment and management of swallowing, feeding, nutritional and hydration status. An individualized management plan should be developed to address therapy for dysphagia, dietary needs, and specialized nutrition plans.
- Videofluoroscopic swallow study (VSS, VFSS, MBS) or fiberoptic endoscopic examination of swallowing (FEES), should be performed on all patients considered at risk for pharyngeal dysphagia or poor airway protection, based on results from the bedside swallowing assessment.
- Restorative swallowing therapy and/or compensatory techniques to optimize the efficiency and safety of the swallow, with reassessment as required, should be considered for dysphagia therapy.
    - Restorative therapy may include lingual resistance, breath holds and effortful swallows.
    - Compensatory techniques may address posture, sensory input with bolus, volitional control, texture modification and a rigorous program of oral hygiene.
- Patients, families and caregivers should receive education on swallowing and feeding recommendations.
- To reduce the risk of pneumonia, patients should be permitted and encouraged to feed themselves whenever possible.
- Patients should be given meticulous mouth and dental care, and educated in the need for good oral hygiene to further reduce the risk of pneumonia.

15.9.3 Low-Risk Feeding Strategies for Dysphagia

The Heart and Stroke Foundation Dysphagia Guidelines (2002) suggested that stroke survivors should be encouraged to feed themselves, and in the cases where assistance is needed it should be provided using low risk strategies. Further*, "routine use of low-risk feeding strategies can prevent serious health problems and improve the quality of the experience for the person being fed. All health care professionals involved in feeding dysphasic individuals should also be able to deal with emergencies, such as choking, which may occur during feeding,"* (Heart and Stroke Foundation of Ontario, 2002).

The HSFO Guidelines for low-risk feeding practices are summarized in Table 15.9.3.1.

Table 15.9.3.1 Heart and Stroke Foundation of Ontario Guidelines for low-risk feeding practices (2002)

•Check the food tray to ensure the correct diet type has been provided.
•Ensure the environment is calm during meals and minimize distractions.
•Position the stroke survivor with the torso at 90 degree angle to the seating plane, aligned in mid-position with the neck slightly flexed.
•Support the stroke survivors with pillows if necessary.
•Perform mouth care before each meal to remove bacteria that have accumulated on the oral mucosa.
•Feed from a seated position, so that you are at eye level with the stroke survivor.
•Do not use tablespoons. Use metal teaspoons, never plastic for feeding individuals with bite reflexes.
•Use a slow rate of feeding and offer a level teaspoon each time.
•Encourage safe swallowing of liquids by providing them with wide-mouth cup or glass or in a cut-down nosey cup, which helps prevent the head from flexing backward and reduces the risk of aspiration. Some individuals may benefit from drinking through a straw.
•Ensure that swallowing has taken place before offering any additional food or liquid.
•Observe the stroke survivor for any signs or symptoms of swallowing problems during and for 30 minutes after the meal.
•Perform mouth care after each meal to ensure that all food debris is cleared from the mouth.
•Position the patient comfortably upright for at least 30 minutes after each meal to promote esophageal clearance and gastric emptying and to reduce reflux.
•Monitor the oral intake of the stroke survivor with dysphagia: note any food items that are not consumed and ensure that intake is adequate, especially important in individuals receiving a thickened-liquid diet.
•Document the patient's intake, any changes in swallowing status and any self-feeding problems.

Conclusions Regarding Low-Risk Feeding Strategies for Dysphagia

Individuals with dysphagia should feed themselves to reduce the risk of aspiration. If hand-over-hand support is not viable and full feeding assistance is necessary, low-risk feeding strategies should be provided by trained personnel.

Individuals with dysphagia should feed themselves whenever possible. When not possible, low-risk feeding strategies are needed.

Summary

1. ***The prevalence of dysphagia in the dysfunction of the pharyngeal phase of swallowing seems to be high. Functional disturbances may vary based on lesion location. Specific measures of pulmonary function seem to be inhibited by dysphagia.***

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

3. ***There is limited level 4 evidence suggesting that the presence of post-swallow vallecular residue may result in a greater risk of penetration-aspiration.***

4. ***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.***

5. ***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.***

6. ***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).***

7. ***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.***

8. ***Age, diabetes, neurological status, and lesion location may be associated with an increase in the rate of dysphagia.***

9. ***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).***

10. ***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.***

11. ***Studies included required affirmative outcomes on two or three of these indicative measures for a positive diagnosis of pneumonia.***

12. ***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.***

13. ***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 of an increased risk of pneumonia.***

14. ***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.***

15. ***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.***
16. ***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 dysphasic patients following stroke compared to placebo. There was no observed effect on mortality.***
17. ***There is level 4 evidence that cilostazol may improve the incidence of pneumonia when compared to patients not given the drug.***
18. ***A large number of different screening methods exist for dysphagia with a wide variation of sensitivity (0-100%), specificity (50-92%) and predictive values.***
19. ***There was a wide range of sensitivity (47.8-100%) and specificity (50-100%) values for the water swallowing test and its variations.***
20. ***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.***
21. ***The GUSS screening tool has 100% sensitivity and 69% specificity to predict aspiration risk.***
22. ***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.***
23. ***There is no ideal volume of water that is used to assess dysphagia on the water swallowing test.***
24. ***There was a wide range of sensitivity (68-97%) and specificity (53-86%) values for the different bedside clinical examinations.***
25. ***Videofluoroscopic Modified Barium Swallow studies are considered the gold standard for dysphagia/aspiration diagnosis.***
26. ***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%).***
27. ***Sensitivity and specificity values for scintigraphy in predicting laryngeal penetration and/or aspiration were between 17-77% and 69-92%, respectively.***
28. ***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.***
29. ***There is level 4 evidence from a large case series study indicating that the incidence of pneumonia may be reduced when dysphasic 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 and length of stay in hospital.***
30. ***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.***
31. ***There is level 2 evidence that both ultrasonography and videofluoroscopy provide comparable***

results.

32. ***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%).***

33. ***There is level 1b and level 2 evidence supporting diets involving thickened liquids improving overall swallow safety and reducing incidence of aspiration pneumonia versus lower viscosity diets.***

34. ***There is level 2 evidence suggesting that thin fluids may be associated with an increase of total fluid intake; however, it is also associated with an increase in aspiration pneumonia.***

35. ***Regarding formal dysphagia therapy, there is level 1a evidence that oral strength training may not be beneficial, while there is level 2 evidence that swallowing therapy and physical therapy are effective in reducing dysphagia.***

36. ***There is level 2 evidence that acupuncture combined with physical therapy is more effective in treating dysphagia than physical therapy alone.***

37. ***There is conflicting level 2 evidence for whether oral feeding or nasogastric tube feeding increases the incidence of aspiration pneumonia among dysphasic patients.***

38. ***There is level 2 evidence that a controlled infusion rate in enteral feeding based on the individual patient's gastric residual volume (GRV) may improve the incidence of regurgitation and aspiration versus no monitoring of the infusion rate.***

39. ***There is level 1b evidence from a large, multicentre RCT that nasogastric tube feeding may decrease the incidence of death and poor functional outcome. The same study suggests that the type of tube feeding may not affect incidence of pneumonia however, there is level 1b evidence from a lower powered RCT suggesting a positive effect of gastro-enteric tubes.***

40. ***There is conflicting level 1b evidence regarding the effect of gastrostomy tubes on mortality, proportion of prescribed feed delivered, and weight gained.***

41. ***It is unclear which method of tube feeding (gastrostomy tube vs. nasogastric tube) is associated with a greater increase in the incidence of pneumonia.***

42. ***There is level 3 evidence that oral intake versus tube feeding may be related to stroke severity.***

43. ***There is level 4 evidence that oral intake versus tube feeding at discharge may be associated with lower age and improved functional independence during acute care.***

44. ***There is conflicting level 1a, level 1b, and level 2 evidence that transcutaneous electrical stimulation may not improve swallowing function when compared to traditional swallowing therapy.***

45. ***There is level 2 evidence from multiple RCTs that NMES is effective in treating dysphagia, more so when combined with traditional therapies.***

46. ***There is level 2 evidence that electrical stimulation may improve swallowing function and the incidence and severity of penetration-aspiration when compared to thermal-tactile stimulation.***

47. ***There is conflicting level 1b and level 2 evidence regarding the effect of intensity and presence of thermal application on the incidence of aspiration and penetration.***

48. ***There is level 1b evidence that swallowing efficiency is improved, specifically among patients with supranuclear lesions after dry swallow preceded by ice massage of the oral cavity.***

49. ***There is level 1b evidence that nifedipine may be associated with improved swallowing function versus placebo. Level 2 evidence indicates that cilostazol prescribed with aspirin may not have an effect on swallowing function compared to aspirin alone.***

50. ***There is level 2 and level 4 evidence that treatment of dysphagia with cabergoline, amantadine, imidapril, or cilostazol may reduce the incidence of aspiration and subsequent pneumonia when compared to no treatment.***

51. ***There is level 1a evidence suggesting that transcranial direct current stimulation (tDCS) may improve functional severity of dysphagia when compared to sham stimulation.***

52. ***There is level 1a evidence that repetitive transcranial magnetic stimulation (rTMS) may improve penetration and aspiration, swallowing function and functional disability compared to sham stimulation.***

53. ***Individuals with dysphagia should feed themselves to reduce the risk of aspiration. If hand-over-hand support is not viable and full feeding assistance is necessary, low-risk feeding strategies should be provided by trained personnel.***

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