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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. It is estimated that between 29 and 50 percent of acute stroke survivors are dysphagic. 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, and physical and olfactory stimulation.

Key Points

Incidence

- There is a high incidence of dysphagia and aspiration following acute stroke.

- The incidence of silent aspiration following acute stroke is high.

- The risk of developing pneumonia following stroke is proportional to the severity of aspiration.

Screening and Detection

- VMBS studies are the only sure way of diagnosing dysphagia and aspiration.

Management

- All stroke survivors should remain NPO until a trained assessor has assessed swallowing ability.

- Following a failed screening, a referral to a Speech-Language Pathologist should be made for further assessment and management.

- Feeding assistance should be provided by an individual trained in low-risk feeding strategies. Individuals with dysphagia should feed themselves whenever possible.

- Dysphagia diets, consisting of texture-modified solid foods and partially thickened fluids may help to reduce the incidence of aspiration pneumonia.

- Treatments with Nifedipine, transcranial magnetic stimulation, transcranial direct current stimulation, and head rotation techniques can be used to improve swallowing mechanics, while thermal stimulation may not.

- Enteral tube feeding may be necessary when stroke patients fail to meet their nutritional needs orally. There is no difference in the outcomes of death or poor outcome associated with the use of either nasogastric or gastro-enteric feeding tubes.

- It is uncertain if the use of electrical stimulation improves swallowing function post stroke.

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15. Dysphagia and Aspiration Post Stroke

Dysphagia is defined as difficulty with swallowing and is a common complication of stroke. The incidence rates are reported to be between 29-67% in acute stroke patients (Martino et al. 2005). 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. Silver et al. (1984)and Bounds et al. (1981) 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; Silver et al. 1984). Steele found that the number of swallowing difficulties seen in stroke survivors was associated with the length of hospitalization (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; 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 (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 tongue transfers the bolus of food 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.

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). Signs and symptoms of dysphagia include: Choking on food, coughing during meals, drooling or loss of food from mouth, pocketing on food in cheeks, slow, effortful eating, difficulty swallowing pills, avoiding food or fluids, complaining of food sticking in throat, problems swallowing, reflux or heartburn (Schmidt et al. 1994). Table 15.1 summarizes the results of studies assessing the pathophysiology of dysphagia post stroke.

Table 15.1 Pathophysiology of Dysphagia Post Stroke

Author, Year Country PEDro Score	Methods	Outcomes
Veis and Logemann (1985) USA No Score	38 stroke patients consecutively referred for VMBS examination for suspicion of swallowing disorders within 4 months of stroke. VMBS studies were used to assess oral and pharyngeal functioning and to identify motility disorders. 3 consistencies were tested: liquid, paste and cookie.	50% of patients demonstrated reduced lingual control, 82% a delayed reflex, 58% reduced pharyngeal peristalsis, 5% reduced laryngeal adduction, 5% crichopharyngeal dysfunction. 76% of patients demonstrated more than one swallowing disorder. 32% of patients aspirated.
Robbins et al. (1993) USA No Score	The swallowing patterns of 20 first -ever MCA stroke patients were compared with 40 control subjects.	Patients with left hemisphere strokes had longer pharyngeal transit duration times compared to controls. Patients with right hemisphere strokes demonstrated longer pharyngeal stage durations and higher incidences of laryngeal penetration and aspiration of liquid. Anterior lesion subjects demonstrated significantly longer swallowing durations on most variables compared to both normal and posterior lesion subjects.

Conclusions Regarding the Pathophysiology of Dysphagia

Dysphagia post stroke is characterized by a delay and reduced function in the pharyngeal phase of swallowing. Although the incidence of dysphagia is more common following brainstem or bilateral hemispheric stroke, it frequently occurs following unilateral hemispheric strokes.

> ***Dysphagia is characterized by reduced coordination of pharyngeal muscles.***

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 et al. 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 15.2.

Table 15.2 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

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). 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). 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.

15.4 Incidence of Dysphagia Post Stroke

15.4.1 Acute Phase of Stroke

Table 15.3 presents results from a variety of studies that used clinical methods to assess swallowing among acute and rehabilitating stroke patients.

Table 15.3 Incidence of Dysphagia Post Stroke (Acute)

Author, Year Country PEDro Score	Methods	Outcomes
Gordon et al.	91 consecutive stroke patients were evaluated	41 (45%) of the patients had evidence of

(1987) UK No Score	with a standardized swallowing test for the presence of dysphagia. 82/90 (92%) were evaluated within 4 days of stroke onset.	dysphagia.
Wade and Hewer (1987) UK No Score	452 consecutive, conscious acute stroke patients were evaluated within 7 days of onset of symptoms. Their ability to swallow water from a cup was evaluated.	194 (43%) of patients were considered dysphagic.
Barer (1989) UK No Score	357 stroke patients selected from a stroke registry participating in the "BEST" study with onset of symptoms within 48 hrs, single-hemisphere involvement, able to take oral medications, no pre-stoke impairments and no cardiac conditions were followed. Ability to swallow 10 mL of water from a cup was assessed.	105 (29%) patients initially presented with dysphagia. By 1 month, 6/277 (2%) of survivors were still dysphagic. At 6 months, 1/248 (0.4%) of those assessed remained dysphagic.
Odderson et al. (1995) USA No Score	124 consecutive, ischemic stroke patients were assessed within 24 hours using a clinical swallowing screen, assessing voice quality, ability to handle oral secretions and ability to swallow ice chips or water briskly.	48 (39%) of patients failed the initial swallow screen. 21 of patients with dysphagia recovered their swallowing function by discharge.
Nilsson et al. (1998) Sweden No Score	100 consecutive, acute stroke patients were assessed for dysphagia within 24 hours of admission. Patients were questioned about swallowing complaints and examined with a repetitive oral suction swallow test (ROSS).	Only 72 patients were able to reliably respond to questions. 14 patients (19%) complained of dysphagia.
Daniels et al. (1998) USA No Score	55 stroke patients consecutively admitted to a VA medical centre. All patients received a bedside and VMBS evaluation within 5 days of admission.	Dysphagia was present in 36 (65%) of patients. Aspiration occurred in 21 (38%) patients.
Mann et al. (1999) Australia No Score	The swallowing function of 128 hospital-referred patients with acute stroke was evaluated clinically and with VMBS studies. Patients were followed for 6 months.	Using VMBS a median of 10 days following stroke, 82 (64%) of patients were diagnosed with dysphagia, 28 (22%) aspirated. Using a clinical exam administered a median of 3 days following stroke, the incidence of dysphagia and aspiration were 51% and 50%, respectively.
Gosney et al. (2006) UK 6 (RCT)	203 patients with first ever stroke were recruited from the acute stroke assessment units from 3 hospitals within 24 hours of onset of symptoms. Patients were evaluated by either a bedside evaluation or a water-swallowing test.	On admission 58 (29%) were considered to be dysphagic.
Smithard et al. (2007) UK No Score	A population-based long-term follow-up of 1,288 persons with first time stroke. Dysphagia was assessed by clinical exam within 1 week of stroke. Patients were followed up at 3 months and yearly for 5 years.	567 (44%) patients were determined to be dysphagic at the point of first assessment.
Remesso et al. (2011) Brazil No Score	A review of 596 patient charts of patients who had experienced an ischemic stroke within 14 days. Presence of dysphagia was determined by clinical examination. Factors associated with dysphagia were explored.	Dysphagia occurred in 117 (19.7%) of patients. The majority of cases (91.5%) were considered mild. Factors associated with dysphagia included increased age, diabetes and brainstem stroke. Spontaneous recovery occurred in 102 (87.3%) within an average of 2.4 months.

Okubo et al. (2012) Brazil No Score	Clinical swallowing assessments were performed in 50 patients following acute stroke and the results compared with NIHSS score ≥ 12, the value selected as a cut-off point to indicate dysphagia.	Dysphagia was present in 16 (32%) patients. 14 of the patients with dysphagia had NIHSS scores ≥ 12 and 29/34 without dysphagia had NIHSS scores <12, representing a sensitivity and specific of 88% and 85%, respectively.
Baroni et al. (2012) Brazil No Score	Clinical swallowing evaluations were conducted on 212 patients admitted following stroke. The majority of evaluations were conducted within the first 5 days of stroke (81%). The remainder were completed within 11 and 60 days of stroke.	134 (63%) patients presented with swallowing difficulties. Of these, 26 (19%) were considered to be mild, 51 (38%), moderate and 57 (43%) severe. 3 month mortality was higher among patients with any swallowing disorder (OR 6.54; 95% CI 2.23 to 19.21).
Flowers et al. (2013) Canada No Score	A review of 221 charts of patients who had experienced an acute stroke or transient ischemic attack was conducted. Presence of dysphagia was defined as diagnosis on clinical examination or as the presence of enteral feeding. Factors associated with the presence of dysphagia were also explored.	98 (44%) of patients were diagnosed with dysphagia. The time to diagnosis was a median of 2.0 days (ranging from 0-26 days) from stroke onset. The odds of experiencing dysphagia were greater for patients with a lower CNS score and lower level of consciousness (OR 1.4, 1.3 to 1.6; OR 2.6, 1.03 to 6.50 respectively).

The studies reviewed above assessed swallowing status in the acute phase of stroke assessed using both clinical and VMBS examination. Among these studies, the incidence of dysphagia ranged from 19% to 65%.

Conclusions Regarding the Incidence of Dysphagia (Acute)

The incidence of dysphagia appears to be quite high following acute stroke with between one third and two-thirds of patients affected, depending on the sample studied and the assessment method used.

There is a high incidence of dysphagia following acute stroke.

15.4.2 Incidence of Aspiration Following Stroke

Several studies have estimated the incidence of aspiration and silent aspiration post stroke using a combination of clinical and radiographic techniques (see Table 15.4).

Table 15.4 Incidence of Aspiration and Silent Aspiration Post Stroke

Author, Year Country PEDro Score	Methods	Outcomes
Veis and Logemann (1985) USA No Score	38 stroke patients consecutively referred for VMBS studies for suspicion of swallowing disorders within 4 months of stroke. VMBS studies to assess oral and pharyngeal functioning and to identify motility disorders. 3 consistencies were tested: liquid, paste and cookie.	50% of patients demonstrated reduced lingual control, 82%, a delayed reflex, 58% reduced pharyngeal peristalsis, 5% reduced laryngeal adduction, 5% crichopharyngeal dysfunction. 76% of patients demonstrated more than one swallowing disorder. 32% of patients

		aspirated.
Horner et al. (1988) USA No Score	47 stroke patients referred for swallowing evaluation on suspicion of dysphagia. To evaluate the clinical correlates of dysphagia, patients received both a clinical and videofluoroscopic evaluation of swallowing function. Liquid, paste and cookie consistencies were tested. 33 patients were tested within the first month post stroke.	51% of patients aspirated on at least one consistency. 54% of the aspirators were silent aspirators. Aspiration was not limited to brainstem or bilateral lesions. Medical-clinical abnormalities appeared to be more frequent in patients who aspirated although no statistical analysis was performed. The presence of a delayed swallow reflex and reduced peristalsis frequently resulted in aspiration. Poor oral motility did not.
Chen et al. (1990) USA No Score	46 consecutive patients with clinical symptoms of dysphagia within one-month of stroke were referred for VMBS examination.	Dysphagia was confirmed by VMBS examination in all cases. Mild swallowing impairment was identified in 18 (39%) patients, moderate dysfunction in 23 (50%) and severe problems in 5 (11%) patients. There were 24 episodes of aspiration.
Splaingard et al. (1988) USA No Score	107 patients referred for evaluation for possible swallowing dysfunction from a general rehabilitation ward, including 87 stroke patients. The results of a bedside swallowing evaluation were compared with VMBS results by blinded evaluators.	40% of patients aspirated during VMBS study. Bedside evaluations identified only 42% of proven aspirators. Silent aspiration, not detected on bedside evaluation was noted in 20% of patients. Bedside assessments identified 58/64 (90%) of non-aspirators.
Kidd et al. (1995) UK No Score	60 consecutive stroke patients admitted to a teaching hospital. Patients received a water-swallowing test and VMBS study within 72 hrs of stroke onset and were re-evaluated at 3 months.	42% of patients aspirated on initial VMBS. 42% of patients were unable to complete the water-swallowing test. Of these, 80% were aspirators. 32% of patients developed a respiratory tract infection (RTI) within 14 days. 89% of RTIs occurred in aspirating patients. 42 patients were re-examined at 3 months. 14% of patients continued to experience impaired pharyngeal sensation. An abnormal water-swallowing test was reported in 7% of the remaining patients. 8% of patients initially presenting with a positive VMBS result also had a positive follow-up test. These same patients developed a respiratory tract infection between days 14 and 90. 5 patients were silent aspirators, accounting for 20% of all aspirators.
Smithard et al. (1996) UK No Score	121 stroke patients consecutively admitted to an urban hospital. Patients received both bedside and VMBS evaluations within 3 days of stroke, when feasible.	50% of the patients were considered to have an unsafe swallow based on bedside evaluation alone. 94 patients had a VMBS study. Of these, 20 (16.5%) patients aspirated. Increased mortality,

		lower Barthel scores and increased frequency of discharge to institutionalized care at 6 months were reported more often in patients with an unsafe swallow. However, these outcomes were not associated with a positive VMBS study result. 22 patients did not receive a 6-month follow-up.
Daniels et al. (1997) USA No Score	59 consecutively admitted ischemic stroke patients received a clinical and VMBS swallowing evaluation within 5 days of admission.	44/59 patients (74.6%) were dysphagic based on VMBS results. Dysphonia, dysarthria, abnormal volitional cough and cough after swallow were all significantly predictive of dysphagia severity.
Daniels et al. (1998) USA No Score	55 stroke patients consecutively admitted to a VA medical centre. All patients received a bedside and VMBS evaluation within 5 days of admission.	Dysphagia was present in 65% of patients. Aspiration occurred in 21 (38%) patients. Of these, 14 aspirated silently (67% of aspirators). Dysphagia was present in 65% of patients. Both abnormal volitional coughing and cough with swallow were highly predictive of aspiration. One patient developed aspiration pneumonia during hospitalization.
Mann et al. (1999) Australia No Score	The swallowing function of 128 hospital-referred patients with acute stroke was evaluated clinically and with VMBS studies. Patients were followed for 6 months.	Using VMBS a median of 10 days following stroke, 82 (64%) of patients were diagnosed with dysphagia, 28 (22%) aspirated. Using a clinical exam administered a median of 3 days following stroke, the incidence of dysphagia and aspiration were 51% and 50%, respectively.
Kim et al. (2000) USA No Score	23 patients with isolated medullary infarctions were assessed using VMBS studies within two weeks of stroke. From the results of the VMBS studies, 2 patient groups were formed: one with aspiration and the other without aspiration. The clinical variables related to aspiration and outcome measures were also explored.	Ten (44%) of the 23 patients manifested aspiration on swallowing. Using criteria including dysphonia, soft palate dysfunction, and facial hypesthesia were used to discriminate between those with and without aspiration with 95.7% accuracy.

Discussion

The incidence of aspiration identified using VMBS studies, assessed during the acute stage of stroke, ranged from 30% to 51%. The incidence of silent aspiration was reported in five studies. The incidence of silent aspirators ranged from 8% (Kidd et al. 1995) to 27% (Horner et al. 1988).

Conclusions Regarding the Incidence of Aspiration Using VMBS

The incidence of aspiration in the acute phase of stroke varies from 30% to 51%.

Conclusions Regarding Silent Aspiration

9 to 27% of acute stroke patients are silent aspirators, a condition which is only reliably detectable through VMBS studies. Between one-third and one-half of aspirators are "silent" aspirators.

> *Aspiration following stroke is very common.*
> *The incidence of silent aspiration following acute stroke is high.*

15.4.3 The Prevalence of Dysphagia in the Rehabilitation Stage Post Stroke

Few studies have examined the prevalence of dysphagia that may persist past the acute stage of stroke. The results from 5 studies that were identified, specific to the rehabilitation period are presented in Table 15.5.

Table 15.5 Prevalence of Dysphagia at Admission to Rehabilitation Post Stroke

Author, Year Country PEDro Score	Methods	Outcomes
De Pippo et al. (1994) USA No Score	139 consecutive patients admitted to an inpatient rehabilitation unit a mean of 5 weeks following stroke. Patients were evaluated using the Burke Dysphagia Screening test (a water swallowing test).	82 (59%) of patients failed the screening tests.
Gottlieb et al. (1996) Israel No Score	180 consecutive rehab patients assessed an average of 14 days post stroke using a bedside technique, which included a water swallowing test (50 mL). A cough during drinking was considered positive.	Dysphagia was diagnosed in 28% of patients.
Terre & Mearin (2006) Spain No Score	138 consecutive patients admitted to a rehabilitation hospital recovering from a severe, first-ever strokes were evaluated clinically and through videofluoroscopy. Evaluations were conducted a mean of 3 months following stroke	Dysphagia was clinically suspected in 64 (46%) of patients. Clinical examination showed that 44% had impaired gag reflex, 47% coughed during oral feeding, and 13% demonstrated changes in voice after swallowing. 42 (30%) patients demonstrated pharyngeal aspiration on VMBS. Of these, 21 (50%) were episodes of silent aspiration.
Poels et al. (2006) The Netherlands No Score	69 stroke patients without aphasia admitted to stroke rehabilitation an average of 34 days following acute stroke. Dysphagia was assessed using structured observations of eating difficulties.	Eating difficulties (including swallowing difficulties) were present in 30 (43%) of patients.
Falsetti et al. (2009) Italy No Score	151 consecutively-admitted patients admitted to a neurorehabilitation unit an average of 14 days following stroke received a 3-step clinical exam, which included 2 water swallowing components (bolus of differing amounts) within one day of admission and a VFS exam for those who failed any portion of the screening test.	62 (41%) of patients were dysphagic, based on the results from the clinical exam. 49/151 patients, 79% of whom were identified as dysphagic based on clinical exam, received a VFS study. Aspiration and silent aspiration were detected in 21 (43%) and 13 (26.5%) patients, respectively.

Discussion

Among five samples of unselected patients entering stroke rehabilitation, the prevalence of dysphagia ranged from 28-59%, using different assessment techniques. In studies which limit patient selection to those recovering from brainstem stroke, the percentages are significantly higher at 40-81% (Chua & Kong 1996; Meng et al. 2000; Teasell et al. 2002).

Conclusions Regarding the Prevalence of Dysphagia in the Rehabilitation Stage of Stroke

A high percentage of patients enter rehabilitation with persistent dysphagia.

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 (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; Logemann & Logemann 1983; 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 15.6), 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 15.6 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 (Table 15.7). Obviously the criteria 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 15.7 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 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.
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. (2004) 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 8 (RCT)	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.

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 dysphagic, bedridden patients who had suffered from a stroke for at least 6 months was 9/14 (63%). The latency of the

swallowing response, assessed by EMG activity and direct observation was greater than 20 sec. In contrast, the latency of response was less than 4 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 15.8 And 15.9 and graphically in figures 15.1 and 15.2. In all cases the incidence of pneumonia was higher among patients with dysphagia and/or aspiration

Table 15.8 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)	1/89 vs. 8/62	13.04 (1.44 to 286)
Combined estimate	**70/398 vs. 34/398**	**2.28 (1.44 to 3.61)**

Figure 15.1. Comparison of Pneumonia Frequency in Stroke Patients between Dysphagic and Non-Dysphagia

Review: Article
Comparison: 01 Incidence of Pneumonia
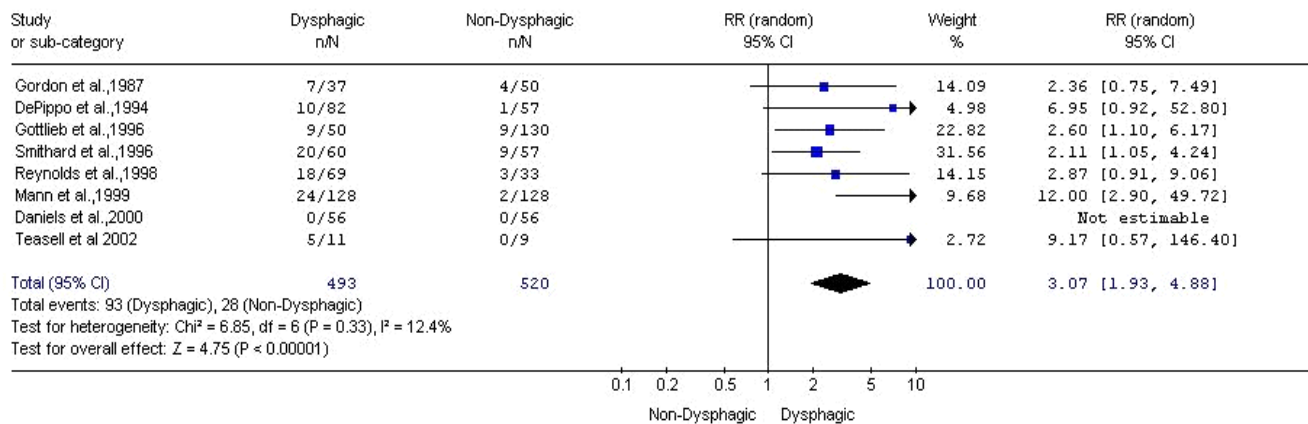Outcome: 01 Figure 1 - Incidence of Pneumonia in Stroke Patients with and without Dysphagia

Study or sub-category	Dysphagic n/N	Non-Dysphagic n/N	RR (random) 95% CI	Weight %	RR (random) 95% CI
Gordon et al.,1987	7/37	4/50		14.09	2.36 [0.75, 7.49]
DePippo et al.,1994	10/82	1/57		4.98	6.95 [0.92, 52.80]
Gottlieb et al.,1996	9/50	9/130		22.82	2.60 [1.10, 6.17]
Smithard et al.,1996	20/60	9/57		31.56	2.11 [1.05, 4.24]
Reynolds et al.,1998	18/69	3/33		14.15	2.87 [0.91, 9.06]
Mann et al.,1999	24/128	2/128		9.68	12.00 [2.90, 49.72]
Daniels et al.,2000	0/56	0/56			Not estimable
Teasell et al 2002	5/11	0/9		2.72	9.17 [0.57, 146.40]
Total (95% CI)	493	520		100.00	3.07 [1.93, 4.88]

Total events: 93 (Dysphagic), 28 (Non-Dysphagic)
Test for heterogeneity: Chi² = 6.85, df = 6 (P = 0.33), I² = 12.4%
Test for overall effect: Z = 4.75 (P < 0.00001)

Table 15.9 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 15.2. Comparison of Pneumonia Frequency in Stroke Patients between Aspirators and Non-Aspirators

Review: Article
Comparison: 01 Incidence of Pneumonia
Outcome: 02 Figure 2 - Incidence of Pneumonia in Stroke Patients - Aspirators vs. Non-Aspirators
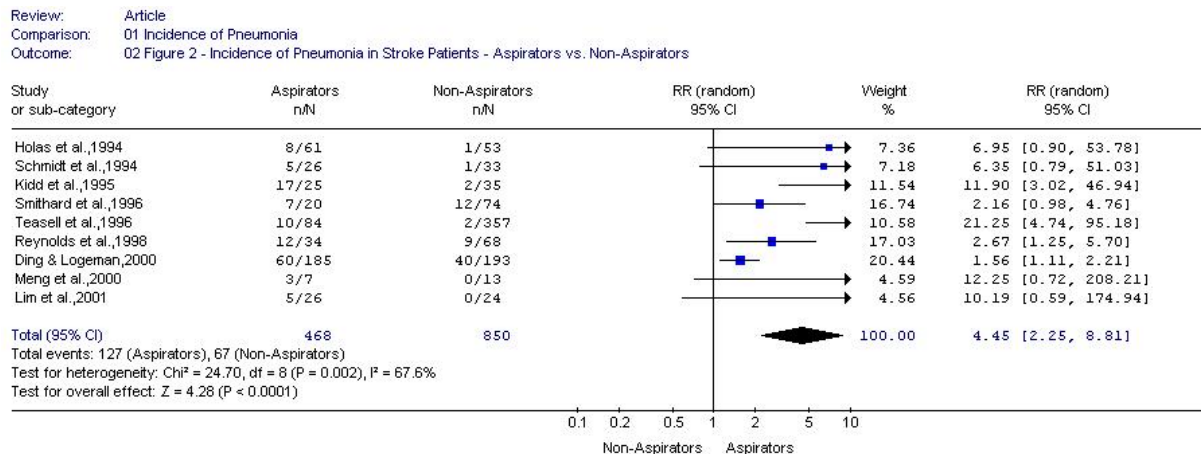
Study or sub-category	Aspirators n/N	Non-Aspirators n/N	RR (random) 95% CI	Weight %	RR (random) 95% CI
Holas et al.,1994	8/61	1/53		7.36	6.95 [0.90, 53.78]
Schmidt et al.,1994	5/26	1/33		7.18	6.35 [0.79, 51.03]
Kidd et al.,1995	17/25	2/35		11.54	11.90 [3.02, 46.94]
Smithard et al.,1996	7/20	12/74		16.74	2.16 [0.98, 4.76]
Teasell et al.,1996	10/84	2/357		10.58	21.25 [4.74, 95.18]
Reynolds et al.,1998	12/34	9/68		17.03	2.67 [1.25, 5.70]
Ding & Logeman,2000	60/185	40/193		20.44	1.56 [1.11, 2.21]
Meng et al.,2000	3/7	0/13		4.59	12.25 [0.72, 208.21]
Lim et al.,2001	5/26	0/24		4.56	10.19 [0.59, 174.94]
Total (95% CI)	468	850		100.00	4.45 [2.25, 8.81]

Total events: 127 (Aspirators), 67 (Non-Aspirators)
Test for heterogeneity: Chi² = 24.70, df = 8 (P = 0.002), I² = 67.6%
Test for overall effect: Z = 4.28 (P < 0.0001)

0.1 0.2 0.5 1 2 5 10
Non-Aspirators   Aspirators

From the pooled results presented above (Figures 15.2 & 15.3) the presence of aspiration was associated with a 4.5-fold increased risk of pneumonia while dysphagia (with or without aspiration) was associated with a 3-fold increase in pneumonia.

Conclusions Regarding the Relationship Between Aspiration and Pneumonia

Dysphagia and aspiration are both associated with an increase in the odds of developing pneumonia. The risk of developing pneumonia appears to be proportional to the severity of the aspiration.

The risk of developing pneumonia following stroke is proportional to the severity of aspiration.

15.6 Non-Instrumental Methods for Screening and Assessment of Dysphagia Following Stroke

Stroke survivors should be screened for dysphagia as soon as possible after acute stroke has been diagnosed and emergency treatment has been given and before any oral intake is allowed. Ideally, screening should take place as soon as the stroke survivor is awake and alert. Stroke survivors who pass the screening are unlikely to have significant swallowing difficulties and have a minimal risk of dysphagic complications. Individuals who fail the screen are maintained NPO until they can be assessed, preferably before the third day after the stroke. On the other hand, screening 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 Table 15.10.

Table 15.10 Description of Screening Tests Used to Identify Dysphagia Post Stroke

Author, Year Name of Test	Components of test Details of validation study	Outcomes
DePippo et al. (1992) The Burke Dysphagia Screening Test	44 consecutive patients on a stroke rehabilitation unit with suspected dysphagia were studied. Patients were given 3 oz of water from a cup and asked to drink without interruption. Coughing for up to 1 minute after the test or a wet-horse voice was considered abnormal. Patients also received a VMBS study and the results from the 2 tests were compared.	The sensitivity and specificity of the WST to detect aspiration were 76% and 59%, respectively
Daniels et al. (1997) "Any Two"	59 acute stroke survivors were studied. Six clinical features-dysphonia, dysarthria, abnormal volitional cough (includes water-swallowing test), abnormal gag reflex, cough after swallow and voice change after swallow were assessed. All subjects received a VMBS study in addition to a clinical exam and water swallowing test.	44/59 patients (74.6%) were dysphagic based on VMBS results. The presence of 2 clinical features correctly distinguished between subjects with normal swallow of mild dysphagia from those with moderate or severe dysphagia as determined by VMBS examination: Sensitivity: 92% Specificity: 67%
Hinds & Wiles (1998) "Timed test"	Standardized questionnaire (11 questions) Timed test of swallowing: subject is given small amount of water from a teaspoon. If successful, 100-150 mL of water is given with the instruction to drink as quickly as possible. A test is considered abnormal if wet hoarse voice or coughing are noted, or if volume of water consumed are below population norms. 115 consecutive subjects with acute stroke. The tool was used to predict the need for SLP intervention.	The ability of the 11 questions to predict the need for a SLP referral: Sensitivity: 0% - 69% Specificity: 62%- 94% The ability of the water swallowing test to predict the need for a SLP referral: Sensitivity: 100% Specificity: 52%
Logemann et al. (1999)	28 items divided into 5 categories: i) 4 medical history variables ii) 6 behavioural variables iii) 2 gross motor variables iv) 9 observations from oromotor testing v) 7 observations during trial swallows The tool was designed to identify the presence or absence of aspiration, oral stage disorder,	Aspiration: Throat clearing was best single predictor. Sensitivity:78% Specificity: 58% Oral stage disorder: dysarthria was the best single predictor. Sensitivity: 64% Specificity:75%

	pharyngeal delay, pharyngeal stage disorder. 202 consecutive patients (34% stroke) were examined. The results were of the screening tool were compared with a VMBS exam.	Presence of pharyngeal delay: being rated as unsafe on at least 8/28 swallowing trials was the best predictor. Sensitivity: 69% Specificity: 71% Pharyngeal stage swallow disorder: reduced laryngeal elevation was the best single predictor. Sensitivity: 72% Specificity: 67%
Trapl et al. (2007) The Gugging Swallowing Screen (GUSS)	Preliminary Assessment (vigilance, throat clearing, saliva swallow) Direct swallow (semisolid, liquid, solid swallow trials) Score: 0 (worst) - 20 (no dysphagia) 80 acute stroke patients were included. Results were compared with fibertopic endoscopic evaluation.	First group of 50 patients: using a cut-off score of 14, the sensitivity of GUSS to identify subjects at risk of aspiration: 100% Specificity: 50% Second group of 30 patients Sensitivity: 100% Specificity: 69%
Martino et al. (2009) The Toronto Bedside Swallowing Screening Test (TOR-BSST)	311 stroke patients (103 acute, 208 rehabilitation) were studied. The tool was designed to identify the presence/absence of dysphagia. Items included: voice before, tongue movement, water swallow and voice after. The results of the screening tool were compared with a subset of subjects who also received a VMBS exam. Scoring: pass-4/4 items; fail ≥1/4 items	Prevalence of dysphagia identified using VMBS: 39% Sensitivity: 91% Specificity: 67% Reliability (based on observations from 50 subjects) ICC =0.92 (95% CI: 0.85-0.96)
Edmiaston et al. (2010) USA Acute Stroke Dysphagia Screen	300 acute stroke patients screened by nurses within 8 to 32 hours following admission. Items included: Glasgow Coma Scale score <13, presence of facial, tongue or palatal asymmetry/weakness. If no to all 3 items, then proceed to 3 oz water swallowing test. If no evidence of swallowing problems on water swallowing test, then the patient passes the screen. Scoring: pass-4/4 items; fail ≥1/4 items Results were compared with the results of the Mann Assessment of Swallowing Ability, performed by a SPL.	Prevalence of Dysphagia identified using MASA: 29% Sensitivity (Dysphagia): 91% Specificity: 74% Sensitivity (aspiration risk): 95% Specificity: 68% Inter-rater reliability: 94% Test-retest reliability: 92.5%

Turner-Lawrence et al. (2009) Emergency Physician Dysphagia Screen	A convenience sample of 84 stroke patients (ischemic/hemorrhagic) was included. Examinations were conducted by 45 ER MDs. The two-tiered bedside tool was developed by SLPs. Tier 1 items included: voice quality, swallowing complaints, facial asymmetry, and aphasia. Tier 2 items included a water swallow test, with evaluation for swallowing difficulty, voice quality compromise, and pulse oximetry desaturation (>or=2%). Patients failing tier 1 did not move forward to tier 2. Patients who passed both tiers were considered to be low-risk. These results were compared with those from a formal assessment by an SLP. Reliability was assessed using a convenience sample of 32 patients.	Prevalence of Dysphagia identified by SLPs: 48 (57%) Sensitivity: 96% Specificity: 56% +Likelihood ratio: 2.2 Reliability: Kappa=0.90
Antonios et al. (2010) Modified Mann Assessment of Swallowing Ability (MMASA)	150 consecutive patients with acute ischemic stroke were assessed by 2 neurologists shortly after admission to hospital. The results were compared with the assessments conducted by SLPs using the full MASA. 12 of the 24 MASA items were retained including: alertness, co-operation, respiration, expressive dysphasia, auditory comprehension, dysarthria, saliva, tongue movement, tongue strength, gag, volitional cough and palate movement. Maximum score is 100.	Prevalence of Dysphagia identified by SLP using MASA: 54 (36.2%) Sensitivity: 87% & 93% Specificity: 86% & 84% + Predictive Value: 79 & 76% + Likelihood Ratio: 5.5 & 6.8 Reliability: Kappa=0.76
Schrock et al. (2011) MetroHealth Dysphagia Screen	283 patients admitted to the Emergency department with acute stroke and screened for the presence of dysphagia by nurses using a 5-item questionnaire. Those results were compared with: an abnormal VMBS study, the placement of a NG/PEG or need for a dysphagia diet at 30 days. Focus of the items: 1. Alert and able to sit upright for 10 minutes. 2. Weak, wet or abnormal voice. 3. Drooling 4. Slurred speech 5. Weak, or inaudible cough.	Incidence of true dysphagia at 30 days was 32% (n=91). VMBS was performed in 77 patients and was abnormal on 64 (83%) patients. Sensitivity: 95% Specificity: 55% + Likelihood Ratio: 2.1 Likelihood ratio: 0.1 Reliability: Kappa=0.69
Edmiaston et al. (2013) Barnes-Jewish Hospital Stroke Dysphagia	225 patients admitted to a stroke unit were assessed for dysphagia and aspiration by a nurse using the BJH-SDS. Results of this test were compared to results of the videofluoroscopic	Prevalence of dysphagia as diagnosed by an SLP using the VFSS was 47%. Sensitivity: 94% (95% CI 88% - 98%)

| Screen (BJH-SDS)

(formerly Acute Stroke Dysphagia Screen – Edmiaston et al. 2010) | swallow study (VFSS) test which was conducted by a (blinded) SLP.

Items of the BJH-SDS included: Glasgow Coma Scale score <13, presence of facial, tongue or palatal asymmetry/weakness. If no to all 3 items, then proceed to 3 oz water swallowing test. If no evidence of swallowing problems on water swallowing test, then the patient passes the screen.

Scoring: pass-4/4 items; fail ≥1/4 items | Specificity: 66% (95% CI 57% - 75%)
PPV: 71% (95% CI 63% - 79%)
NPV: 93% (95% CI 85% - 97%)

Prevalence of aspiration as diagnosed by an SLP using the VFSS was 27%.

Sensitivity: 95% (95% CI 86% - 99%)
Specificity: 50% (95% CI 42% - 58%)
PPV: 41% (95% CI 33% - 50%)
NPV: 96% (95% CI 90% - 99%) |

In addition to multiple component tests, standalone tests can be used to screen for dysphagia. We examine two variations of the water swallowing test in the two tables below.

15.6.2 The Water Swallowing Test

The water-swallowing test has also been studied extensively. It has been used as both a standalone screening method and also as part of a clinical swallowing screening or assessment. While the original test required a patient to swallow 3 oz (90 mL) of water, lesser amounts have also been used. The optimal amount of water to use in water-swallowing tests was assessed in a study by Osawa et al. (2013). The psychometric properties of the test were assessed using 3 mL, 5mL, 10mL, 30mL, or 60mL volumes in a set of patients with suspected dysphagia after stroke. The results this study and others that have evaluated this technique, are detailed in Table 15.11.

Table 15.11 Sensitivity and Specificity of the Water-Swallowing Test

Author, Year Country PEDro Score	Methods	Outcomes
Garon et al. (1995) USA No Score	100 patients (50% stroke) with confirmed or suspected dysphagia that required a VMBS study as part of clinical management. All patients were asked to drink 3 oz. of water from a cup without interruption. Any coughing or throat clearing was indicative of an abnormal water-swallowing test (WST). The results of the 2 methods were compared.	The sensitivity and specificity of the tool to identify confirmed aspirators were 54% and 79%, respectively.
Lim et al. (2001) Singapore No Score	50 acute stroke patients received a 50 mL water swallowing test (in 10 mL aliquots) and a FEES examination. Patients also received an oxygen desaturation test.	The 50-ml water swallow test had a sensitivity of 84.6% and specificity of 75.0%. The oxygen desaturation test had a sensitivity of 76.9% and specificity of 83.3%. When the two tests were combined into one test called "bedside aspiration," the sensitivity rose to 100% with a specificity of 70.8%. Five (10%) patients developed pneumonia during their inpatient stay. The relative risk (RR) of developing

		pneumonia, if there was evidence of aspiration on FEES, was 1.24 (95% CI 1.03, 1.49).
Chong et al. (2003) Singapore No Score	50 patients with suspected dysphagia, 65 years or older, who had suffered either a recent or remote stroke. Patients received a clinical evaluation of swallowing which included a water swallowing test (WST), where patients were asked to drink 50 mL of water in 10mL aliquots, and an oxygen desaturation test (desaturation of ≥ 2% was considered clinically significant) and an objective test, fiberoptic endoscopic evaluation of swallowing (FEES), where episodes of aspiration or penetration of various food consistencies were noted. The consistency or results between the tests were compared.	The WST had a sensitivity of 79.4% and specificity of 62.5% for the detection of aspiration, with a positive predictive value (PPV) of 81.8% and a negative predictive value (NPV) of 58.8%. The oxygen desaturation test had a sensitivity of 55.9% and a specificity of 100% with PPV of 100% and NPV of 51.6%. When both tests were combined, a sensitivity of 94.1% and a specificity of 62.5% were attained, with PPV of 84.2% and NPV of 83.3%. Using the clinical assessment test, 3 aspirators were detected who would otherwise have been missed if they were assessed with the water swallow test using thin fluids alone.
Tohara et al. (2003) USA & Japan No Score	63 nursing home patients (57%) stroke with clinical evidence of dysphagia were studied to assess the accuracy of three non-VFG tests for risk of aspiration: (1) the water swallowing test (3 ml of water are placed under the tongue and the patient is asked to swallow); (2) the food test (4 g of pudding are placed on the dorsum of the tongue and the patient asked to swallow); and (3) the X-ray test (static radiographs of the pharynx are taken before and after swallowing liquid barium). The results of these tests were compared with those of a VMBS study conducted within one-week of the after the water and food tests.	29 patients aspirated on the VFSS. The summed scores of all three non-VFG tests had a sensitivity and specificity of 90% and 71%. The summed scores of the water and food tests (without X-ray) had a sensitivity of 90% and specificity of 56%.
Wu et al. (2004) Taiwan No Score	59 stroke outpatients with suspected dysphagia underwent a 100 mL water-swallowing test. Signs of choking or a wet sounding voice within 1 minute of completing the test were considered evidence of an abnormal swallow. Swallowing speed (< 10 mL/s or ≥ 10 mL/s) was also recorded. The results were compared to a VMBS study.	55 patients were identified as having some form of swallowing dysfunction on VMBS examination. An abnormal swallowing speed was detected in 47/55 patients. 2 patients with a normal VMBS result demonstrated abnormal swallowing speed on the WST. The sensitivity and specificity of the test was 85.5% and 50%, respectively. 33 patients either aspirated or demonstrated penetration on VMBS study. Of these 11 choked on the WST, while 3 patients with a normal VMBS result, choked on the WST. The sensitivity and specificity of the test was 47.8% and 91.7%, respectively.
Nishiwaki et al. (2005) Japan	61 consecutive stroke patients admitted to 4 hospitals were assessed for dysphagia. Symptoms of oromotor functions were evaluated (lip closure, tongue movement,	Cough/voice change in the water swallowing test was the only variable that was significantly

No Score	palatal elevation, gag reflex, voice quality and motor speech function). The water swallowing test (using 30 mL of water), saliva swallowing test and a VMBS examination were also conducted. Factor analysis was used to predict dysphagia in patients following stroke.	associated with aspiration on VMBS examination with sensitivity of 72% and a specificity of 67%.
Kopey et al. (2010) USA No Score	A retrospective review of 223 patients admitted to an acute rehabilitation unit who were alert, and non-dysarthric. These patients received a 3-sip test on day 2 following admission. A portion of the patients underwent additional VMBS due to continued suspicion of dysphagia. The sensitivity (SN), specificity (SP), positive and negative predictive values (PPV, NPV)of the sip test compared with clinically relevant dysphagia, defined as VMBS findings that precipitated a diet change (i.e. minced or pureed solids) were calculated.	206 patients passed the 3-sip test. 67 (32.5%) patients had clinically significant dysphagia. The reported SN and SP were 20.8% and 98.7%, respectively and the PPV and NPV were 88.2% and 72.3%. A low (<60) FIM score was also predictive of clinically relevant dysphagia.
Osawa et al. (2013) Japan No Score	111 patients with suspected dysphagia after stroke were assessed by videoflurography (VF). Results of this test were compared to a clinical assessment performed by a (blinded) speech therapist. Scoring for clinical assessment: Choking or gargling voice or decrease in oxygen saturation (SpO_2). SpO_2 decrease of greater than 2% was classified as abnormal.	The number of aspirations experienced by patients increased as the amount of liquid increased (17 occurrences at 5mL to 70 occurrences at 60mL). The sensitivity of the WST was greatest at 60mL (55.7%), while the specificity of the WST was greatest at 10mL (93.2%). Positive predictive value was greatest at 60mL (86.7%) and negative predictive value was greatest at 5mL (91.4%). A specific volume of water (3mL, 5mL, 10mL, 30mL, 60mL) did not stand out as most appropriate across all psychometric properties of the WST.

An alternative test (the two step thickened water test) has been developed to assess paste food aspiration (Momosaki et al. 2013) (Table 15.12). 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.

Table 15.12 Sensitivity and Specificity of a Two-Step Thickened Water Test

Author, Year Country PEDro Score	Methods	Outcomes
Momosaki et al. (2013) Japan No Score	110 patients who failed a water swallowing test and were suspected of having pharyngeal dysphagia were included. The fiberoptic endoscopic evaluation of swallowing (FEES) was used as the gold standard to compare the results of the two-step thickened water test (TTWT) for identifying paste-food aspiration. Results of the TTWT were also compared to the two-step water test (TWT) in the same	The TTWT had a sensitivity, specificity, positive predictive value and negative predictive value of 93.3%, 87.7%, 84%, and 95% respectively. The TWT was equally as sensitive, but had a lower specificity of diagnosing paste-food

sample of patients.		aspiration compared to the TTWT.

15.6.3 Swallowing Provocation Test (SPT)

The 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). This manoeuvre elicits an involuntary swallow. The latent time is then timed 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.

Table 15.13 The Water Provocation Test

Author, Year Country PEDro Score	Methods	Outcomes
Teramoto & Fukuchi (2000) Japan No Score	A retrospective comparative trial of 26 stroke patients with aspiration pneumonia and 26 age-matched controls without pneumonia were selected to assess the properties of a swallowing provocation test (SPT) and a water swallowing test (WST) in detecting aspiration pneumonia in elderly patients. The normal response to SPT was determined by inducing swallowing reflex within 3 seconds after water injection into the suprapharynx. In WST, subjects drank quantities of 10 and 30mL of water from a cup within 10 seconds. A test was considered normal if the subject drank water without interruption and without evidence of aspiration.	The sensitivity and specificity of first-step SPT for the detection of aspiration pneumonia were 100% and 83.8%, respectively. Those of the second-step SPT were 76.4% and 100%, respectively. The sensitivity and specificity of first-step WST using 10mL of water for the detection of aspiration pneumonia were 71.4% and 70.8%, respectively. Those of the second-step WST using 30mL of water were 72% and 70.3%, respectively.
Warnecke et al. (2008) Germany No Score	100 patients with first-ever stroke were examined by SPT and fiberoptic endoscopic evaluation of swallowing (FEES) within 72 hours of stroke onset. A two-step approach was used. In the first step 0.4 ml of distilled water was used. In step 2, 2.0 ml was used.	The incidence of endoscopically proven aspiration risk was 81%. The 1st-step SPT had a sensitivity of 74% and a specificity of 100%. The 2nd-step SPT had 49% sensitivity and 100% specificity.
Kagaya et al. (2010) Japan No Score	The sensitivity (SN) and specificity (SP) of the 2-step swallowing provocation test (SPT) compared with VMBS results to detect aspiration, silent aspiration and penetration was evaluated among 45 rehabilitation inpatients, 27% with stroke.	The SNs and SPs of the first-step SPT for the detection of aspiration, silent aspiration, or penetration were 72-75% and 38-44%, respectively. The SNs and SPs of the second-step of the SPT were 13-17% and 80-89%, respectively.

We have presented 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, and 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.

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 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 5 mL water swallowing test, dysarthria, abnormal volitional cough, abnormal voice and abnormal pharyngeal sensation. Only 1 item (impaired pharyngeal response) was associated with a likelihood ratio greater than 10, the clinically relevant threshold.

15.6.4 The Bedside Clinical Examination for Assessment of Dysphagia

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, while others evaluate swallowing ability using a more comprehensive approach. These methods may or may not include a water-swallowing test. Many of these methods have been described previously in the section on screening and share common features (Table 15.14).

Table 15.14 Components of Various Bedside Techniques to Screen for or Assess Dysphagia

Author, Year Name of test	Components of test Details of validation study	Results
Smithard et al. (1997) Bedside Swallowing Assessment	121 stroke patients consecutively admitted to an urban hospital. Patients were given an assessment of conscious level, head and trunk control, breathing pattern, lip closure, palate movement, laryngeal function, gag and voluntary cough (includes water-swallow test). Patients received both bedside and VMBS (n=94) evaluations within 3 days of stroke. Both an MD and a SLP each conducted the bedside exam.	50% of the patients were considered to have an unsafe swallow based on bedside evaluation alone. Of these, 20 (16.5%) patients aspirated on VMBS. Sensitivity of bedside exam to detect aspiration on VMBS: 47% (SLP); 68% (MD). Specificity: 86% (SLP); 67% (MD)
Mann et al. (2002) Mann Assessment of Swallowing Ability	128 acute first-ever stroke patients received both a bedside and VMBS exam. General examination: Consciousness, cooperation, language function, verbal/oral praxis, articulation 24 items including-	65 (51%) subjects demonstrated evidence of dysphagia on bedside exam and 28 (21.9%) demonstrated evidence of aspiration on VMBS exam. Using a cut-off score of <180 the

	Oral preparation: Control of saliva, lip seal, tongue movement/strength, oral preparation, assessment of respiration Oral phase: Gag reflex, palatal movement, oral transit time, bolus clearance Pharyngeal phase: Pharyngeal control/pooling, laryngeal elevation, reflex/voluntary cough, voice quality Includes water swallowing test Scoring for dysphagia: No abnormality ≤178-200 Mild ≤ 168-177 Moderate ≤ 139-167 Severe ≤ 138	sensitivity and specificity of bedside assessment to detect dysphagia were 71% and 72%. The sensitivity and specificity of bedside assessment to detect aspiration were 93% and 53%.

15.6.5 Other 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), 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 Dysphagia Screening and Non-instrumental Assessment Techniques

Although a wide variety of screening and assessment tests are available for use, none have acceptable sensitivity and specificity to ensure accurate detection of dysphagia.

15.7 Instrumental Methods Used in the Detection of Dysphagia/Aspiration

15.7.1 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 15.14). 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 15.15 Radiological Evaluation During VMBS (from 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

- Chronic changes
- Presence of barium in valleculae, pyriform sinuses, tracheoboncheal 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).

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). FEESST was shown to be a safe technique 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).

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, absent from VMBS evaluation, information which was used to more effectively guide management.

Rather than attempt to compare the accuracy of swallowing abnormalities assessed between VMBS and FEES evaluations Leder & Espinosa 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. Two studies used FEES as the gold standard to assess the accuracy of either the water-swallowing test and/or pulse oximetry to detect aspiration (Chong et al. 2003; Lim et al. 2001).

Table 15.16 Studies Evaluating FEES

Author, Year Country PEDro Score	Methods	Outcomes
Aviv (2000) USA No Score	78 outpatients referred for dysphagia evaluation were assigned to a VMBS group to guide swallowing management, while 61 patients received FEES with sensory testing. The incidence of pneumonia over a one-year period between groups was compared. Patients received feeding tubes, therapy from a speech-language pathologist based on the results obtained from the VMBS/FEES test results.	There was no difference in the incidence of pneumonia between the groups. At the end of one-year 14 (18.4%) patients whose management had been guided by MBS developed pneumonia, compared with 6 (12%) patients in the FEES group (p< 0.20). However, among 45 stroke patients the incidence of pneumonia was lower among FEES group patients (1/21 vs. 7/24, p<0.05).
Leder & Espinosa (2002) No Score	53 consecutive stroke patients referred for swallowing assessment were evaluated for the presence of aspiration using a bedside evaluation which was immediately followed by a FEES examination. FEES was used as the diagnostic standard.	The clinical exam correctly identified 19/22 patients considered at risk for aspiration. The clinical exam incorrectly identified 8/27 patients to be at risk of aspiration. The sensitivity and specificity of the clinical assessment were 86% and 30%, respectively. The corresponding positive and negative predictive values were 50% and 73%.

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 bronchospam 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. However, the accuracy of pulse oximetry in detecting aspiration is unproven and it remains uncertain whether oxygen desaturation can predict aspiration. 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, while Collins & Bakheit (1997) reported that pulse oximetry could be used to detect a high proportion of stroke patients who aspirated on VMBS.

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).

Table 15.17 Studies Evaluating Pulse Oximetry

Author, Year Country PEDro Score	Methods	Outcomes
Collins & Bakheit (1997) UK No Score	54 consecutive stroke patients with swallowing difficulties were studied. Patients received a VMBS study and simultaneously had their arterial oxygen saturation measured. The barium meal consisted of 150 mL liquid, 3 oz. mousse and biscuit. A drop of $\geq$2% in the arterial oxygen saturation was considered clinically significant. Oxygen saturation was measured during swallowing, 2 minutes after the test meal and 10 minutes after the	22 patients demonstrated aspiration on VMBS evaluation. Correlation of the pulse oximetry results with VMBS findings showed that 12 (55%) of the patients who aspirated had a significant degree of oxygen desaturation at the point of swallow/aspiration, but none of the nonaspirators desaturated by $\geq$2%. When the results of oximetry at swallow/aspiration and at

	VMBS study was completed.	2 minutes after swallowing were combined, 16 (73%) of the aspirators could be identified by this method, and 4 (13%) of the nonaspirators also had a significant oxygen desaturation. In total, 44 patients (81.5%) were accurately predicted as aspirators or nonaspirators (κ=0.61, *P*<.001). Prediction was better for males compared to females. The sensitivity and specificity of pulse oximetry were 73% and 87%, respectively.
Sellars et al. (1998) UK No Score	Six patients (4 with stroke) with established dysphagia underwent both VMBS evaluation with simultaneous oxygen saturation monitoring. Decline in O_2 saturation of 4% from baseline was considered clinically significant.	4 patients demonstrated aspiration of VMBS. Of these, 2 exhibited significant O_2 desaturation.
Sherman et al. (1999) USA No Score	46 (16 with stroke) with swallowing difficulties underwent VMBS evaluation with simultaneous oxygen saturation monitoring (with a 5-6 second sampling interval).	12/46 patients (6 with stroke) aspirated on VMBS. Patients who aspirated had a significantly greater decline in oxygen saturation compared to those who did not aspirate. The lowest O_2 saturation value among patients who aspirated was 81% compared with 92% among patients who did not aspirate/penetrate.
Smith et al. (2000) UK No Score	53 consecutive patients with acute stroke received a bedside evaluation, pulse oximetry and a VMBS evaluation of swallowing. The sensitivity (SN), specificity (SP), positive predictive value (PPV) and negative predictive value (NPV) were calculated for both the bedside evaluation and pulse oximetry.	15/53 patients aspirated on VMBS examination. The SN, SP, PPV and NPV for pulse oximetry to identify aspiration were 87%, 39%, 36% and 88%, respectively.
Wang et al. (2005) Taiwan No Score	60 patients (27 with stroke) received both oxygen saturation and VMBS evaluation. Oxygen saturation was monitored for 5 minutes before and for 5 minutes after the VMBS evaluation.	23/60 patients demonstrated aspiration on VMBS examination. Of these patients 9 displayed significant oxygen desaturation (a drop of > 3% was considered significant. Of the 37 patients who did not demonstrate aspiration on VMBS, 15 had an episode of oxygen desaturation. The sensitivity and specificity were 39.1% and 59.4%, respectively. The positive and negative predictive values were 37.5% and 61.1%, respectively. The positive likelihood ratio was 0.96.
Ramsey et al. (2006) UK No Score	189 stroke patients received a bedside swallowing assessment (BSA), pulse oximetry and VMBS (n=54) studies. Two cut-points were selected to determine the presence/absence of oxygen destauration (>2% and >5%).	15 (28%) demonstrated aspiration on VMBS. Of these, 2% destauration was seen in 5 (33.3%) of these patients and in 2 (13.3%) when >5% threshold was used. 7/15 patients (47%) with demonstrated aspiration, failed the BSA. The sensitivity and specificity associated with >2% destauration were 33% and 62% and were 13% and 95% for an oxygen desaturation threshold of >5%.

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.

15.7.4 Ultrasonography

Ultransography 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). Huang and colleagues (2009) found ultrasongraphy to be a reliable method for evaluating hyoid-larynx approximation in dysphagic stroke patients. A more recent study evaluated ultrasonography for identifying tube-feeding-dependent dysphagia using cut points for tongue thickness and hyoid bone displacement (Hsiao et al. 2012). This study suggests that ultrasonography offers useful information regarding a patients swallowing function. Results are outlined in Table 15.18.

Table 15.18 Studies Evaluating Ultrasonography

Author, Year Country PEDro Score	Methods	Outcomes
Hsiao et al. (2012) Taiwan No Score	90 individuals (60 stroke patients admitted to a rehabilitation ward - 30 with tube-feeding, 30 with oral intake, and 30 age-matched healthy controls) were assessed for swallowing function using ultrasonographic examination. Each participant performed 3 swallows (5mL of water each). Measures of tongue thickness and hyoid bone displacement were recorded and compared between groups.	Using a cut-off point for tongue thickness of 1.0cm, the sensitivity and specificity of detecting patients in need of tube feeding using ultrasonography was 70.0% and 66.7% respectively. Using a cut-off point for hyoid bone displacement of 1.5cm, the sensitivity and specificity of detecting patients in need of tube feeding using ultrasonography was 73.3% and 66.7% respectively. There were no statistically significant differences in these measures as compared to findings from the VFSS.

15.8 Management of Aspiration 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.

Conclusions Regarding Instrumental Methods to Detect Dysphagia Post Stroke

The VMBS study is considered the gold standard to detect silent aspiration. Other methods such as FEES and pulse oximetry are also in use.

15.8.1 Management Strategies for Dysphagia

The Heart and Stroke Foundation Dysphagia Guidelines noted that, "a well-coordinated care plan can minimize the development of dysphagic 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.

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).

15.8.2 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 (Heart and Stroke Foundation of Ontario 2002). These are summarized in Table 15.19.

Table 15.19 Best Practice Guidelines for Managing Dysphagia Post-Stroke (HSFO 2002)

• Maintain NPO until swallowing status is determined
• Regular oral care, with minimum of water to limit build-up of bacteria
• Screen for swallowing status by trained team member once awake and alert
• Screen for risk factors of poor nutrition early by trained team member
• Swallowing assessment necessary for all those who fail swallowing screen
• Swallowing assessment by speech-language pathologist to:
- assess ability to swallow
- determine swallowing complications
- identify associated factors which may be compromising swallowing and nutrition
- recommend appropriate individualized management program, including appropriate diet
- monitor hydration status
• Where appropriate feeding assistance or mealtime supervision by individuals trained in low-risk feeding strategies
• Assess nutrition and hydration status and needs of those who fail screening; reassess regularly
• Education of patient and family into follow-up upon discharge
• Consider the wishes and values of the patient and family concerning oral and non-oral nutrition; provide information to allow informed choices.

Conclusions Based on Best Practice Guidelines for Managing Dysphagia

There is consensus (Level 3) opinion that acute stroke survivors should be NPO until swallowing ability has been determined.

There is consensus (Level 3) opinion that a trained assessor should screen all acute stroke survivors for swallowing difficulties as soon as they are able.

There is consensus (Level 3) opinion that a speech and language pathologist should assess all stroke survivors who fail swallowing screening and identify the appropriate course of treatment.

There is consensus (Level 3) opinion that an individual trained in low-risk feeding strategies should provide feeding assistance or supervision to stroke survivors where appropriate.

There is consensus (Level 3) opinion that a dietician should assess the nutrition and hydration status of all stroke patients who fail swallowing screening.

All stroke survivors should remain NPO until a trained assessor has assessed swallowing ability.

Feeding assistance should be provided by an individual trained in low-risk feeding strategies where appropriate,

Following a failed screening assessment, all patients should be assessed by a Speech-Language Pathologist and an appropriate management plan be initiated.

15.8.3 Dysphagia Screening Protocols

A few studies have evaluated whether the implementation of dysphagia screening protocols resulted in a reduction in the incidence of pneumonia (Table 15.20). A recent study assessed cough reflex testing as an initial screen prior to oral protocols.

Table 15.20 Dysphagia Screening Protocols

Author, Year Country PEDro Score	Methods	Outcomes
Odderson et al. (1995) USA No Score	The incidence of pneumonia was assessed in a single institution before the implementation of a dysphagia screening protocol, during the first year after its implementation and during the second year.	The percentages of patients who developed pneumonia before the pathway was developed, during the first year of the pathway and during the second year of the pathway were 6.7%, 4.1% and 0%, respectively.
Hinchey et al. (2005) USA No Score	15 acute care hospital sites were surveyed to determine whether they had an established dysphagia screening protocol in place and to establish the adherence level. The incidence of pneumonia between institutions which had/ did not have formal screening in place was compared.	6 sites had a formal dysphagia screen. Their adherence rate was 78% compared with 57% at sites with no formal screen. The pneumonia rate at sites with a formal dysphagia screen was 2.4% versus 5.4% (p=0.0016) at sites with no formal screen. There was no difference in median stroke severity (5 versus 4; P=0.84) between the sites with and without a formal screen.
Lakshminarayan et al. (2010)	Adherance to gudielines for dysphaia screening was examined in a National Acute Stroke Registry. The	The sample was composed of 18,017 patients from 222 hospitals. 4,509 (25%) of patients were not screened.

USA No Score	incidence of pneumonia among patients who were screened/not screened assessed prior to initiation of oral intake.	Pneumonia rates were 4.2% in patients who were not screened, 2.0% in patients who were screened and passed and 6.8% for patients were screened but failed.
Yeh et al. (2011) Taiwan No Score	176 consecutive acute stroke patients admitted to the stroke ICU from May 2006 to March 2007 were included. Patients were divided into two groups- those who were admitted before the introduction of standardized dysphagia screening (n=74) and those admitted after the introduction of the 3-Step Swallowing Screen (n=102). A binary logistic regression model was used to determine independent risk factors for stroke associated pneumonia and in-hospital death.	100 patients (57%) developed pneumonia although there was no difference in its development between patients who were screened and those who were not (45 vs. 55, p=0.44). Pneumonia was associated with greater stroke severity, older age, nasogastric and endotracheal tube placement and length of tube placement. After adjusting for age, gender, NIHSS score and nasogastric and endotracheal tube insertion, dysphagia screening was associated with a borderline decrease in pneumonia (OR: 0.42; 95% CI, 0.18-1.00; p=0.05). However, dysphagia screening was not associated with reduction of in-hospital deaths
Miles et al. (2013) New Zealand 7 (RCT)	311 patients who were referred to a speech language pathologist after acute stroke were included. Patients were randomized to either standard swallowing evaluation (n=163) or standard evaluation plus cough reflex testing (n=148). Cough reflex testing involved the use of a PulmoMate Compressor/Nebuliser to deliver a flow of citric acid solutions (diluted in NaCl) to induce a cough reflex. The flow was delivered 3 times for 15 seconds each, and patients were asked to cough if they felt it necessary. This process was repeated with patients being asked to try to suppress the cough reflex. A test was considered failed if the patient had only 1 or no cough reflex in either round. Primary outcome was the presence of pneumonia at 3 months.	There were no statistically significant differences in the presence of pneumonia in the experimental vs. the control group (26% vs. 21%; P=0.38). Clinical practices were associated with the initial cough reflex test. The proportion of patients referred for instrumental assessment was higher for those that failed the cough test (P<0.0001), and dietary recommendations were different according to cough test results.
Sorensen et al. (2013) Denmark No Score	146 patients with acute stroke and moderate or severe dysphasia were included (intervention group = 58, historical control group = 58, external control group = 30). The intervention group received the Gugging Swallowing Screen (GUSS) to screen for dysphagia, whose score was used to determine dietary recommendations. The GUSS was repeated prior to each meal in the acute phases. Patients also received care for oral hygiene (brushing, protecting, moistening and antibacterial protection – 0.12% chlorhexidine two times per day). The control group received usual care which was based on formal dysphasia screening recommendations ("clincial screening method within 24 hours and before oral administration of nutrition or fluids"). Primary outcome was incidence of x-ray verified pneumonia.	There were statistically significant differences in the incidence of x-ray verified pneumonia between the three groups (intervention group 7%, historical control 28% (P<0.01), and external control 27% (P<0.05)). Dysphagia screening also took place within 24 hours for 97% of patients in the intervention group, compared to 72% in the historical control group (P<0.01). A greater number of individuals in the intervention group also had a care plan for oral hygiene prepared (71% vs. 10% in the historical control group P<0.01).

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. obviously

impaired patients are not screened as they are assumed to be dysphagic) (Lakshminarayan et al. 2010). The authors suggested that clinical judgement is not adequate and endorsed the practice of routine dysphagia screening.

Conclusions Regarding the Benefits of Dysphagia Screening Protocols
There is limited (Level 2) evidence that dysphagia screening protocols can reduce the incidence of pneumonia.

15.8.4 Low-Risk Feeding Strategies for Dysphagia

The Heart and Stroke Foundation Dysphagia Guidelines noted that, "Stroke survivors should be encouraged and assisted to feed themselves. Individuals with dysphagia who are fed are approximately 20 times more likely to develop pneumonia than those who feed themselves (Langmore et al. 1998). Therefore, if dysphagic individuals cannot feed themselves independently, hand- over-hand support should be provided from an eye level position. If full feeding assistance is necessary, it should be provided using low risk feeding strategies.

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 dysphagic 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 15.21.

Table 15.21 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 900 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 Feeding Strategies in Dysphagia

There is limited (Level 2) evidence that individuals with dysphagia should feed themselves to reduce the risk of aspiration.

For patients who require assistance to feed, there is a consensus (Level 3) opinion that low-risk feeding strategies by trained personnel should be employed.

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

15.9 Specific Interventions to Manage Dysphagia

Previous Reviews

A Cochrane systematic review evaluated the benefit of different management strategies for dysphagia following stroke (Bath et al. 1999). The review included 6 studies, including an abstract and unpublished data, assessing how and when to feed, oral supplementation and how and when to treat. Although few studies were available, enteral feeding via PEG was associated with improved nutrition and lower adverse events compared to NG tube feeding, and nutritional supplementation was associated with improved energy and protein intake. There was no evidence supporting the use of fluid supplementation, swallowing therapy or drug therapy. Further details of the review can be found in Section 15.10.

A recent systematic review also evaluated the efficacy of a broader range of dysphagia treatments including: texture-modified diets, general dysphagia therapy programmes, non-oral (enteral) feeding, medications, and physical and olfactory stimulation (Foley et al. 2008). In this review, 15 RCTs were identified. In contrast with the findings of the Cochrane review, there was evidence that nasogastric tube feeding was not associated with a higher risk of death compared to percutaneous feeding tubes. General dysphagia therapy programmes were associated with a reduced risk of pneumonia in the acute stage of stroke.

15.9.1 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 although they 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).

The prevention of aspiration by the use of texture-modified foods is not assured. The risk of aspiration of pureed food was recently reported by Perlman et al. 204 stroke patients were divided into six groups based on the results of laryngopharyngeal sensory testing, assess by flexible endoscopic evaluation

(Perlman et al. 2004). No patients with both normal sensation and pharyngeal squeeze aspirated pureed consistency foods. The percentage of aspirators increased to 67% in patients with moderately decreased sensation and absent motor function. The results of this study suggest that motor strength may be more important than sensory impairment in the prediction of aspiration.

Over time, particularly in the earlier 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 (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). The restrictions associated with a diet of thick fluids can eliminate all thin liquids. 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.

The Heart and Stroke Dysphagia Guidelines noted "*Diet texture modification, however, can reduce an individual's enjoyment of food, resulting in decreased oral intake. This can rapidly lead to dehydration and eventually to malnutrition. Also, the use of starch-based food thickeners increases carbohydrate intake, which may produce a nutritional imbalance if the diet is not carefully monitored. Controlling dietary carbohydrates is especially important in individuals with diabetes. It is therefore critical to consult a dietitian to ensure that the modified diet is nutritionally adequate and appropriate, and to consult the stroke survivor or substitute decision-maker to ensure that the modified diet is as appealing as possible,*" (Heart and Stroke Foundation of Ontario 2002).

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 dysphagic 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. Currently no randomized controlled studies have demonstrated whether these modified diets influence outcome although a large multi-centered trial has been completed and the results are pending publication (Dennis 1997).

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 dysphagic 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).

In a recent study, Diniz et al. (2009) examined 61 acute stroke patients for signs of aspiration after receiving both thin liquids and pudding-like feeds using nasoendoscopy. Aspiration occurred in only 3 patients with the spoon-thick consistency vs. 21 with the liquid consistency (relative risk=0.13; 95% confidence interval=0.04-0.39; P<.001). There were no episodes of laryngeal penetration with pudding-like fluids and 8 incidences with thin liquid. Patients in this study all had feeding tubes in situ. However, Leder & Suiter reported than the placement of NG feeding tubes did not increase the risk of aspiration for liquid or pureed food consistencies (Leder & Suiter 2008). This study included dysphagic patients with a broad range of etiologies, including stroke. The sample size was large (n=1,260).

Dietary management is often directed by the results of the VMBS studies. Studies examining the efficacy of fluid modifications are presented in Table 15.22.

Table 15.22 Studies of Dietary Modifications in Dysphagia

Author, Year Country PEDro Score	Methods	Outcomes
Groher (1987) USA 3 (RCT)	56 stroke patients with chronic dysphagia, on a pureed diet prior to study and at least 1 month post resolution of aspiration pneumonia were randomized to receive: i) a soft mechanical diet and thickened liquids or ii) pureed foods and thin liquids. The recurrence of aspiration pneumonia over a 6-month period was assessed.	Study group had fewer occurrences of aspiration pneumonia (5 vs. 28, p<0.05). (If persons who developed pneumonia on more than one occasion are ignored the incidence of pneumonia was still lower in the study group: 4 vs. 18).
Garon et al. (1997) USA 5 (RCT)	20 dysphagic stroke patients were randomized to receive either a regular dysphagia diet including thickened fluids (control group) or to a dysphagia diet which allowed the inclusion of unlimited amounts of water (study group) between meals.	No patient in either group developed dehydration or pneumonia within the 30- day trial period, or required intravenous fluids. There were no significant differences in total fluid intake between the groups. However, patients in the study group drank significantly less thickened fluid compared to patients in the control group.
Goulding & Bakheit (2000) UK 6 (RCT)	46 dysphagic inpatients were randomized to receive thickened fluids prepared using conventional subjective assessment of viscosity or fluids thickened with the aid of viscometer for 7 days.	Higher viscosity of fluid prepared using subjective assessment. There were no significant differences in the incidence of aspiration between the groups. Strong correlation between increased viscosity and portion of thickened fluid that was not consumed.
Perlman et al. (2004) USA No Score	204 dysphagic patients underwent assessment of swallowing function and sensory evaluation with flexible endoscope. Patients were then divided into 3 groups, with normal, moderate and severe sensory deficits. Each group was divided into those with impaired/normal pharyngeal squeeze. Patients were then tested for aspiration following a pureed food bolus.	Sensation Motor Function Aspiration (%) Normal Normal 0 Normal Absent 14 Mod decrease Normal 0 Mod decrease Absent 67 Severe/absent Normal 6 Severe/absent Absent 40
Diniz et al. (2009) Brazil	61 patients, 19 with acute stroke received a trial of either liquid or spoon-thick liquids in random order	Aspiration occurred in 24 patients. A higher proportion of patients aspirated with liquid samples (3 vs. 21,

6 (RCT)	and were assessed for evidence of dysphagia (penetration, aspiration or residue) using nasoendoscopy. Patients also underwent a clinical examination and bedside clinical assessment.	p<0.001). There was no evidence of penetration among patients given spoon-thick liquids compared with 8 instances following liquid challenges (p<0.006).
McGrail et al. (2013) United States No Score	20 patients and 10 healthy community controls were included in the study. The patient sample was comprised of individuals diagnosed with ischemic stroke and receiving etiher a thin liquid diet (n=10) or thick liquid diet (n=10). Fluid intake for all three groups was evaluated over a period of 72 hours and included only consumption of liquids typically considered beverages. 1500mL of fluids was considered a minum standard daily intake.	The community group was found to have significantly greater fluid intake than the hospital groups (1961 $\pm$ 529mL/day vs. 1237$\pm$442mL/day (thin liquid group) vs. 947$\pm$144mL/day (thick liquid group). The thin liquid group also had significantly greater fluid intake than the thick liquid group (P=0.04). Only one patient in the thin liquid group exceeded the minimum fluid intake standard, while no patients in the thick liquid group acheived the minimum standard.
Park et al. (2013) USA No Score	30 patients who had been referred for videofluoroscpic swallowing examination (VFSE) were included (15 patients who aspirated; 15 patients who did not aspirate). Patients were asked to swallow boluses of differing consistency (thin liquid, nectar thick liquid and puree) and oropharyngeal (oral transit time and pharyngeal transit time) transit times were recorded.	There were no significant differences in oral transit times between aspirators and nonaspirators for each bolus consistency (F=0.08; P=0.78). Transit times differed depending on bolus consistency (F=22.68; P<0.01). Transit times increased with higher viscosity of the bolus. For pharyngeal transit times, aspirators had statistically significantly longer transit times than nonaspirators (F=5.90; P=0.019). These differences were significant for the nectar thick liquid and the puree, but not for thin liquids (P=0.02; P<0.01; P=0.41)
Momosaki et al. (2013) Japan No Score	52 patients who were referred for videofluoroscopy with suspected pharyngeal dysphagia were included. Patients were randomly assigned a semisolid bolus to swallow and were subsequently evaluated for residue in the pharynx, penetration of the bolus into the larynx and aspiration.	Residue in the pharynx was significantly greater for food textures that were measured as more cohesive (P=0.005). No association was found between the amount of residue and hardness, adhesiveness, or gumminess. Tracheal aspiration was found to be more common with gummier bolus textures (P=0.03), but not with respect to the other texture properties. There was no association between laryngeal penetration and hardness, adhesiveness, cohesiveness or gumminess.

Conclusions Regarding Dietary Modifications

There is consensus (Level 3) opinion that dysphagic stroke patients, who are considered safe with oral intake, require diets with modified food and liquid textures. Although dietary modifications have been used to help reduce the risk of aspiration and their consequences following stroke, the evidence in support of their use is lacking. Further research is needed in this area.

There is limited (Level 2) evidence that dysphagia diets reduce the incidence of aspiration pneumonia.

There is moderate (Level 1b) evidence that thickened fluids result in fewer episodes of aspiration and penetration compared with thin fluids among dysphagic individuals following stroke.

> *Dysphagic stroke patients should be provided with an appropriate modified diet, after consultation with a dietitian.*

15.9.2 Swallowing Treatment Programs

Several studies have examined the effect of formal dysphagia therapy on a variety of outcomes. Dysphagia therapy usually involves a combination of approaches, including exercises aimed at strengthening muscles, and improving movement and coordination. Possible exercises may include the Mendelsohn maneuver (the patient hold the larynx up, either using the muscles of the neck or with the hand, during the 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 therapies are usually provided in addition to dietary modifications.

DePippo et al. (1994) conducted the only RCT, which demonstrated no benefit of formal dysphagia therapy. However, the two-week treatment period may have been too short to actually demonstrate 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.
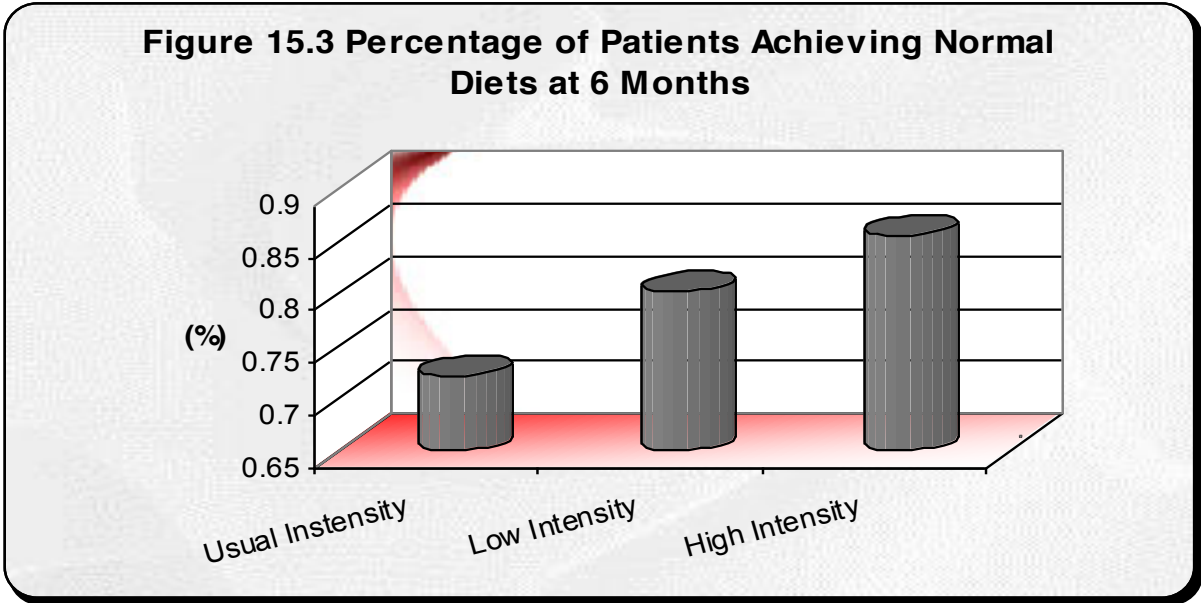
Odderson et al. (1995) in an unrated retrospective study found the introduction of a stroke program with dysphagia therapy improved dysphagia-related outcomes. Lin et al. (2003) also reported improvements in various nutrition parameters and choking frequency among patients who participated in a swallowing training program. Takahata et al. (2011) restricted their inclusion to patients recovering from acute ICH and reported that patients who received an early oral care and behavioural interventions could tolerate oral early feeding earlier than control patients.

Table 15.23 Studies of Dysphagia Therapy Post Stroke

Author, Year Country PEDro Score	Methods	Outcomes
DePippo et al. (1994) USA 5 (RCT)	115 patients randomized to receive either one formal dysphagia treatment session and choice of modified-texture diet, one dysphagia session with prescribed texture-modified diet or daily intervention by SLP and prescribed diet.	Up to 1 year follow-up revealed no significant differences between the 3 groups in the incidence of pneumonia, dehydration No deaths were reported. Only one instance of recurrent upper airway obstruction.
Odderson et al. (1995) USA No Score	124 patients with non-hemorrhagic stroke admitted to an urban community hospital. Within 24 hours of admission, patients received a clinical swallowing evaluation and received appropriate dysphagia interventions if required, as per the protocol of a recently implemented clinical pathway. The incidences of aspiration pneumonia, LOS and outcome disposition were recorded (criteria for defining pneumonia was not reported). Functional outcome was assessed using FIM.	48 (39%) patients were diagnosed with dysphagia on admission. No incidences of aspiration pneumonia were reported. The year prior to the introduction of the pathway, 6.7% of patients developed aspiration pneumonia. The first year the pathway was introduced, 4.1% of patients developed aspiration pneumonia. Patients without dysphagia had a shorter LOS and were more likely to be discharged to the community. Patients who passed the initial swallowing screen had higher FIM scores compared to those who failed.
Lin et al. (2003) Taiwan No Score	A quasi-experimental parallel, cluster design study that recruited 61 patients (2:1) from 7 long-term care facilities to receive either swallowing training or no therapy (Patients received therapy following data collection). Swallowing training consisted of direct	The results of between group comparisons on change scores (pre-test, post-test) showed statistically significant improvements favouring the treatment group for: swallowing function (incidence of coughing/choking, volume/second

	therapies (compensatory strategies, diet modification, environmental arrangement, the Mendelsohn manoeuvre, supraglottic swallowing and effortful swallowing) and indirect therapies (thermal stimulation, oral motor and lingual exercises and were provided 30 min/days 6 days/week x 8 weeks.	swallowed, volume per swallow), neurological examination and nutrition parameters (mid-arm circumference and weight)
Carnaby et al. (2006) USA 8 (RCT)	306 patients with clinical dysphagia admitted to hospital with acute stroke were randomly assigned to receive usual care (n=102), standard low-intensity intervention (n=102), or standard high-intensity intervention and dietary prescription (n=102). Treatment continued for up to a month. The primary outcome measure was survival free of an abnormal diet at 6 months	Of patients randomly allocated usual care, 56% (57/102) survived at 6 months free of a modified diet compared with 64% (65/102) allocated to standard (low-intensity) swallowing therapy and 70% (71/102) patients who received high-intensity swallowing therapy. Compared with usual care and low-intensity therapy, high-intensity therapy was associated with an increased proportion of patients who returned to a normal diet (p=0.04) and recovered swallowing (p=0.02) by 6 months. Results also presented in Figure 15.3.
Takahata et al. (2011) Japan No Score	The outcomes of 2 groups of patients admitted with ICH were compared. The first group (n=90) was admitted before the implementation of an early intervention program delivered mainly by nurses. The second group (n=129), after its implementation. The intervention program included screening prior to the initiation of oral intake using pudding or jelly (not water), intensive oral care, postural adjustment during feeding with chin tuck and advancement of the diet, as appropriate. The primary outcome was the proportion of patients who could tolerate early feedings (defined as a score of 4-7 on the 7-item Functional Oral Intake Scale at the point of discharge.	The proportion of patients who could tolerate oral feeding was significantly higher in the early intervention group compared with the control group: 112 (86.8%) vs. 61 (67.8%), p<0.001. After adjusting for baseline imbalances, early intervention was still associated with oral feeding tolerance (OR: 4.42; 95% CI, 1.81-10.8; P = 0.001). The incidence of chest infection was lower in the early intervention group compared with the control group 27/129 (20.9%) vs. 32/90 (35.6%); odds ratio 0.48, 95% CI, 0.26-0.88; P = 0.016).
McCullough et al. (2012) USA No Score	18 patients with dysphagia after first stroke (average 9.5 months since stroke) were randomly assigned to either Group 1 (two weeks of treatment, two weeks of no treatment) or Group 2 (two weeks of no treatment, two weeks of treatment). The two week treatment regime involved two sessions per day (45 min/session), and required patients to perform a series of 30-40 swallows using the Mendelsohn maneuver per session. Before each swallow, a small amount of water was placed in the mouth using a dental swab (for the purposes of facilitating swallowing). The duration of Hyoid maximum anterior excursion (HMAE), hyoid maximum elevation (HME) and the mean width of the UES opening (MWUESO) were, as well as Penetration/Aspiration scale, oropharyngeal residue and dysphagia outcome severity scale (DOSS) for each swallow.	17 patients had follow up data available. There were significant improvements in duration of HME (P=0.011) and duration of HMAE (P=0.009) at 2 weeks post treatment compared to baseline values. No other statistically significant results were found.
McCullough & Kim (2013) USA	18 patients with dysphagia after first stroke (average 9.5 months since stroke) were randomly assigned to either Group 1 (two weeks of treatment, two weeks of no treatment) or Group 2 (two weeks of no treatment, two weeks of treatment). The two week treatment regime	17 patients had follow up data available. There were no significant differences between the distance measures (HME. HMAE, MWUESO) (F= 1.875; P=0.135) after the treatment period vs. after the no treatment period. Within the

involved two sessions per day (45 min/session), and required patients to perform a series of 30-40 swallows using the Mendelsohn maneuver per session. Before each swallow, a small amount of water was placed in the mouth using a dental swab (for the purposes of facilitating swallowing). Hyoid maximum anterior excursion (HMAE), hyoid maximum elevation (HME) and the mean width of the UES opening (MWUESO) were measured (and the duration of each measure), as well as Penetration/Aspiration scale, oropharyngeal residue and dysphagia outcome severity scale (DOSS) for each swallow.	treatment period however, there were significant differences in all distance measures between the first and second weeks of treatment (HME P=0.01; HMAE P=0.05; MWUESO P=0.016). There were no statistically significant results at one month follow-up.

Figure 15.3 Percentage of Patients Achieving Normal Diets at 6 Months

Conclusions Regarding Dysphagia Therapy

There is moderate (Level 1b) evidence that a short course of formal dysphagia therapy does not alter clinical outcomes.

There is moderate (Level 1b) evidence that while a one-month dysphagia intervention program does not improve the likelihood of returning to a normal diet by six months, it may reduce the likelihood of chest infections and death or institutionalization.

> *A short course of formal dysphagia therapy may not alter clinical outcomes.*

15.9.3 Non-Oral Feedings

Non-oral or tube feeding in neurogenic aspiration has become a well-established rehabilitation practice. The Heart and Stroke Dysphagia Guidelines state, "Enteral feeding is recommended if a swallowing assessment indicates high-risk dysphagia or inability to meet nutritional needs orally. Enteral feeding

should be considered after a stroke survivor has been NPO for 48 hours and implemented within 3-4 days. If dysphagia is severe and expected to last for more than 6 weeks, a gastrostomy or jejunostomy feeding tube may be indicated," (Heart and Stroke Foundation of Ontario 2002). Of course anticipating the expected duration of the requirement for non-oral feeding is challenging. Recently, factors associated with a quicker swallowing recovery were identified (Nakajima et al. 2012). They included younger age (<75 yrs), independence prior to admission and an NIHSS score of ≤9 on day 10 post stroke. 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) (Heart and Stroke Foundation of Ontario 2002; 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 15.24 presents two studies, which have investigated this relationship.

Table 15.24 Studies which Examine the Risk of Aspiration Pneumonia Associated with Enteral Feeding

Author, Year Country PEDro Score	Methods	Outcomes
Nakajoh et al. (2000) Japan No Score	The incidence of pneumonia was prospectively analyzed for 1 year in three groups of post-stroke patients on the basis of the following clinical conditions: oral feeding without dysphagia (n = 43); oral feeding with dysphagia (n = 48); and nasogastric tube feeding with dysphagia (n = 52). The incidence of pneumonia in bedridden patients with nasogastric tube feeding (n = 14) was also studied. Pre-study, the swallowing and cough reflexes of each patient were measured. The swallowing reflex was evaluated according to latency of response, which was timed from the injection of 1 mL of distilled water into the pharynx through a nasal catheter to the onset of swallowing.	The incidence of pneumonia was significantly higher in patients with oral feeding than in those with tube feeding (54.3% vs. 13.2%, P < 0.001). In bedridden patients with tube feeding, the latency of response was longer than 20 sec and no patient coughed at the highest concentration of citric acid. The incidence of pneumonia was 64.3% in such patients. The state of protective reflexes had a significant relation to the incidence of pneumonia. Feeding tube placement may have a beneficial role in preventing aspiration pneumonia in mildly or moderately disabled post-stroke patients with attenuated protective reflexes.
Dziewas et al. (2004) Germany No Score	Over an 18-month period, 100 consecutive acute stroke patients who were fed by a naso-gastric feeding tube because of dysphagia were prospectively evaluated.	Pneumonia was diagnosed in 44% of the tube fed patients. All pneumonias occurred while the tube was in situ. Most patients acquired pneumonia on the second or third day after stroke onset. Patients with pneumonia more often required endotracheal intubation and mechanical ventilation than those without pneumonia. Independent predictors for the occurrence of pneumonia were a decreased level of consciousness and severe facial palsy.
Mamum & Lin (2005) Singapore	122 patients admitted to a geriatric ward (75% with stroke) were assessed by a SLP. Following assessment patients were recommended to have either oral feeding with modified diet or nasogastric tube feeding. The incidence of aspiration pneumonia among patients on	90 patients were recommended for non-oral feeding. Of these, 64 agreed and 26 refused and were fed orally. 32 patients were deemed safe with an oral, modified diet. There were 14 cases of aspiration pneumonia confirmed using pre-

	oral feeding, nasogastric (NG) tube feeding and patients who refused nasogastric tube feeding were compared.	defined criteria during the 2-month follow-up, resulting in death in 5 cases. 12 of these cases were reported among patients fed by an NG tube, 2 in patients who refused NG tubes and no cases were reported among patients deemed safe on an oral diet. Four of the 5 deaths occurred in the NG group. The difference was statistically significant
Leder et al. (2008) USA No Score	1260 consecutively enrolled inpatients, 630 with an NG tube in place and 630 without at the time of assessment for dysphagia. The aspiration status of all subjects was established using FEES. 3 trials each of both pudding and thin fluid consistencies were trialed.	There were no significant differences in aspiration of either liquid or puree food consistencies dependent on presence of an NG tube. The analysis was adjusted for sex, age, or diagnostic category.
Langdon et al. (2009) Australia No Score	A cohort of 330 ischemic stroke survivors were followed for 30 days to determine whether the risk of pneumonia was higher in tube fed patients compared with orally fed.	Over the study period the number of respiratory infections in tube fed and orally fed patients were 30/51 (59%) and 21/64 (33%), respectively. The risk of pneumonia was increased in tube fed patients (RR=4.94, 95% CI 3.02-8.10, p<0.001).

Dziewas et al. (2004) reported an extremely high rate of pneumonia among 100 acute stroke patients who were fed via a 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, while it remains uncertain whether NG tubes pose a higher risk for the development of pneumonia following, 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.

Although there was no comparison group, the high incidence of pneumonia raises troubling concerns about the effectiveness of feeding tubes in preventing pneumonia in high-risk populations. Marum & Lim (2005) also 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.

In contrast to findings from these 2 studies, Nakajoh et al. (2000) reported that the incidence of pneumonia was 4.1 times greater among 73 dysphagic stroke patients who were orally fed (n=35), 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.

In contrast to these findings Langdon et al. (2009) reported an increased risk in the incidence of pneumonia associated with tube feeding. There was also a significant time-to-event effect with 73%

(22/30) respiratory infections in tube-fed survivors diagnosed on days 2-4 after stroke, and 76% (39/51) of infections in all tube-fed survivors occurring by day 7 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.

Conclusions Regarding the Use of Non-Oral Feeding

There is consensus (Level 3) opinion that enteral tube feeding be used in stroke patients who are dysphagic and at high risk for aspiration or who cannot meet their nutritional needs orally. Enteral feeding should be considered after a stroke survivor has been NPO for 48 hours.

Although enteral feeding for dysphagic stroke patients is a well-established practice, there is conflicting (Level 4) evidence that nasogastric tubes reduce the risk of pneumonia.

Enteral tube feeding should be considered for stroke patients at risk of aspiration.

15.9.4 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, clinically, it can be 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 and which are positioned directly into the stomach (with extensions into the small bowel) or small intestine either percutaneously or surgically. Generally, gastro-enteric tubes are used for long-term feeding. 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; Park et al. 1992), although significant mortality and morbidity has been associated with more invasive enteric tubes, such as the percutaneous endoscopic gastrostomy (PEG) (Anderson et al. 2004). Anderson et al. (2004) describes 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. Table 15.25 presents the results of several studies evaluating the nasogastric and percutaneously placed feeding tubes.

Table 15.25 The Efficacy of Non-Oral Feeding Post Stroke: Gastric/gastro-jejunal vs. NG Feeding Tubes

Author, Year Country PEDro Score	Methods	Outcomes
Park et al. (1992) Scotland 6 (RCT)	28 days of enteral feeding using either a percutaneous endoscopic gastrostomy (PEG) tube or naso-gastric (NG) tube was evaluated in 40 patients (18 with stroke) with long-standing (>4 weeks) dysphagia.	Treatment failure occurred in 18/19 patients in NG group compared to 0/19 in PEG group Patients in NG group received less volume of feed compared to PEG group (55% vs. 93%).
Norton et al. (1996) UK	30 dysphagic stroke patients randomized to receive either a gastrostomy feeding tube (GT) or a nasogastric tube (NG).	At 6 weeks post stroke, a significantly greater proportion of patients died in the NG group compared to the GT group (8 vs. 2). Patients in

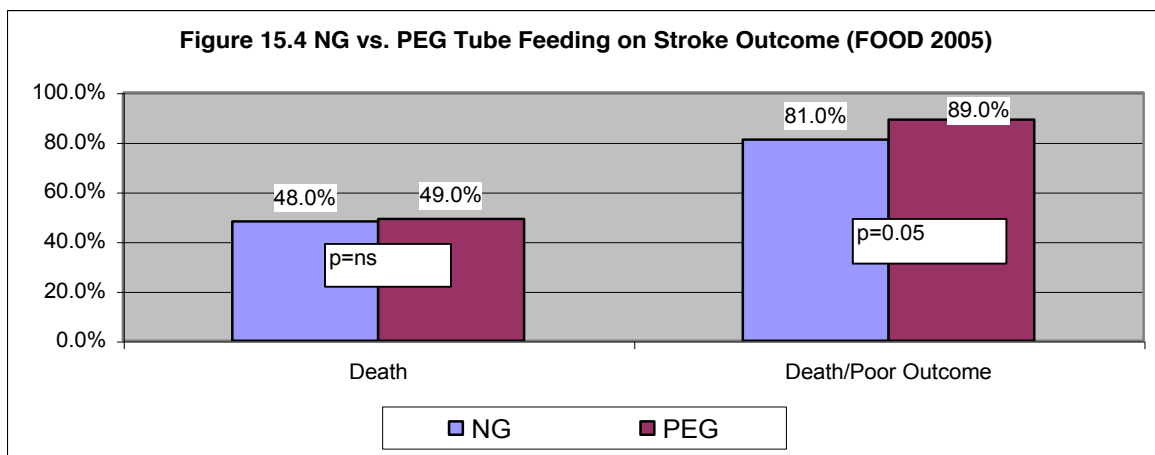| 6 (RCT)		the GT group had better nutritional indices including weight, serum albumin, and mid-arm circumference. There were no omitted feeds among patients in the GT group compared to at least one missed feed in 10 patients in the NG group.
Lien et al. (2000) Taiwan No Score	8 stroke patients with a modified feeding tube in place allowing for both gastric (PEG) and jejunal (PEJ) feeding were tested for gastroesophageal reflux using 24 hr esophageal pH monitoring.	24 hr esophageal acid exposure (% of time that pH readings was <4) were significantly lower on PEJ feeding days compared to PEG feeding days (10.1% vs. 20.6%). During meal infusion, 7/8 patients had less esophageal acid exposure during PEJ feeding compared to PEG feeding.
Dennis et al. (2005) UK 7 (RCT)	321 acute stroke patients, from 47 hospitals in 11 countries, were randomized to receive either a PEG (n=162) or NG feeding tube (n=159) within 3 days of enrolment into the study. Death and poor outcome (defined as a Modified Rankin Score of 4-5) was assessed at 6 months.	Feeding with a PEG tube was associated with an increase in the absolute risk of death or poor outcome of 7.8% (p=0.05). There was no difference in the incidence of pneumonia between the groups. There were more gastrointestinal bleeds among patients in the NG group (18 vs. 5, p=0.005), but more pressure sores among patients in the PEG group (12 vs. 4, p=0.04). Only 48% of patients allocated to treatment in the PEG group actually received the treatment within 3 days.
Kostadima et al. (2005) Greece 6 (RCT)	41 acutely ill, ventilator dependent patients with a diagnosis of either stroke (n=25) or head injury (n=16) were randomized to receive a gastrostomy or to NG tube for enteral feeding. Tubes were inserted within 24 hours of intubation. Patients were followed for 3 weeks and the incidence of pneumonia was noted and compared between groups. A diagnosis of pneumonia was established using previously validated criteria.	At the end of weeks 2 and 3 the cumulative incidence of pneumonia was significantly higher in the NG compared to the gastrostomy group (p<0.05). At the end of the first week the incidence of pneumonia was higher in the gastrostomy group although the result was not statistically significant. Gastrostomy NG Week 1 2/20 1/20 Week 2 2/18 8/19 Week 3 2/16 8/18
Beavan et al. (2010) UK 7 (RCT)	104 patients requiring non-oral feeding following acute stroke received an NG tube which was secured using either conventional means (adhesive tape) (n=53) or a nasal loop (n = 51). The main outcome measure was the proportion of prescribed feed and fluids delivered via NGT in 2 weeks. Secondary outcomes were frequency of NGT insertions, treatment failure, tolerability, mortality; length of hospital stay; residential status; and Barthel Index at 3 months.	Subjects in the nasal loop group received a significantly greater volume of prescribed feeds and fluids over 2 weeks (75% vs. 57%, p=0.02) and required fewer NG tubes (median 1 vs.4). There were no differences in outcomes at 3 months (death, BI scores. Death or dependency, length of hospital stay.

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 15.26. 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. The results from the largest and most important of the trials (Dennis et al. 2005) are presented in Figure 15.4.

Table 15.26 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)

Figure 15.4 NG vs. PEG Tube Feeding on Stroke Outcome (FOOD 2005)

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 3 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.

Conclusions Regarding Choice of Feeding Tube

There is consensus (Level 3) opinion that if dysphagia is severe and expected to last more than 6 weeks, a gastrostomy or jejunostomy feeding tube may be indicated.

Based on the results from two "good" quality RCTs, there is strong (Level 1a) evidence that intragastric feeding devices are associated with fewer
mechanical failures compared to nasogastric feeding tubes.

Based on the results from one large, international trial, there is moderate (Level 1b) evidence that the type of feeding tube (nasogastric or gastro-enteric) does not affect the odds of death or the combined outcome of death or poor functional outcome.

There is moderate (Level1b) evidence that the risk of developing pneumonia is higher among ventilated patients fed by a naso-gastric tube compared with a gastrostomy tube.

There is moderate (Level 1b) evidence that securing naso-gastric tubes with a tether-like device reduces the number of dislodged tubes and increases the amount of required feed and fluids that patients receive.

> *Enteral tube feeding may be necessary when stroke patients fail to meet their nutritional needs orally. Gastric or jejunostomy feeding tubes are preferred over nasogastric tubes for providing nutrition and hydration to dysphagic patients who require non-oral support for more than 28 days.*

15.9.5 Transcutaneous Electrical Stimulation

Electrical stimulation involves the administration of small electrical impulses to the muscles associated with swallowing in the throat through electrodes attached to the skin. It is usually used in addition to conventional swallowing therapy.

Although electrical stimulation is widely used clinically in the United States, there is a lack of evidence supporting its use. A recent meta-analysis, which included the results from 7 trials reported a large effect size associated with the treatment (Carnaby-Mann & Crary 2007). The participants in the individual trials were dysphagic due to a variety of conditions, including stroke. The results from the 3 trials included in the present review suggested that the effectiveness of the electrical stimulation has not yet been established when compared to traditional swallowing therapy.

Table 15.27 Effectiveness of Transcutaneous Electrical Stimulation For Post-Stroke Dysphagia

Author, Year Country PEDro Score	Methods	Outcomes
Park et al. (1997) UK No Score	Case reports of 4 dysphagic stroke patients receiving electrical stimulation of the palatal area to improve swallowing function.	Improvement in swallowing function in 2/4 patients including a reduction in transit time and absence of pooling/penetration/aspiration.
Freed et al. (2001)	Controlled trial whereby 99 dysphagic stroke patients	Mean swallowing scores between the groups

USA No score	were assigned to receive either thermal-tactile stimulation (TS) or electrical stimulation (ES). TS was given in 3-20 minutes daily sessions. A small mirror was chilled in ice and then applied to the anterior faucial arch. In ES treatment, the electrodes of a hand-held stimulator were placed on the neck in one of two positions until muscle fasciculations occurred. Frequency and pulse width were fixed at 80Hz and 300 ms. Swallowing function was assessed before and after treatment using a 0 (worst) to 6 (best) aspiration scale. Treatment continued until patient achieved a score of 5 or was discharged from hospital.	were similar at baseline. At the time of final assessment the mean swallowing scores were significantly higher among patients in the ES groups compared to the TS group (4.52 vs. 1.13). 98% of ES patients showed some improvement, whereas 27% of TS patients remained at initial swallow score and 11% got worse. These results are based on similar numbers of treatments (average of 5.5 for ES and 6.0 for TS).
Power et al. (2006) UK 4 (RCT)	16 dysphagic stroke subjects were randomized to receive treatment consisting of stimulation of the anterior faucial pillar with either no (sham) stimulation or stimulation at a frequency of 0.2 Hz for 10 minutes (5 on each side). Swallowing was assessed before and 60 min after electrical or sham stimulation. Swallowing measures included laryngeal closure (initiation and duration) and pharyngeal transit time, taken from VMBS study. Aspiration severity was assessed using an 8-point scale.	Compared with baseline, no change was observed in the speed of laryngeal elevation, pharyngeal transit time, or aspiration severity within subjects or between groups for either active or sham stimulation.
Bülow et al. (2008) Sweden 3 (RCT)	25 stroke patients from 3 European swallowing centers were randomized to receive a 3-week trial (15 sessions) of either neuromuscular electrical stimulation (NMES) or traditional swallowing therapy (TT). Measurements including videoradiographic swallowing evaluation, nutritional status, oral motor function test, and a visual analog scale (VAS) for self-evaluation of complaints, were assessed before and after treatment.	While subjects in both groups improved over the treatment period there were no statistically significant differences on any of the outcomes.
Permsirivanich et al. (2009) Thailand 6 (RCT)	23 stroke patients with dysphagia persisting for > 2 weeks were randomized to receive either rehabilitation swallowing therapy (RST) or neuromuscular electrical stimulation therapy (NMES). The subjects received 60 minutes of either RST or NMES treatment for five consecutive days, had two days off and then five more consecutive days of treatment for a four-week period or until they reached functional oral intake scale (FOIS) level 7. FOIS, the primary outcome measure, was assessed before /after treatment. FOIS score 1=NPO, FOIS score 7= oral diet, no restrictions	Before therapy, 73% of the RST group and 83% of the NMES group required non-oral feeding (FOIS levels 1-3). At the end of the study period, 75% of the RST group and 90% of the NMES group could manage oral intake (FOIS groups 4-7). The differences in proportions were not statistically significant. 18% of RST and 17% of the NMES subjects had attained a FOIS score of 7. There was a significant difference in the change scores, favouring the NMES group (+3.17 vs. 2.46, p<0.001)
Lim et al. (2009) Korea No Score	36 received thermal-tactile stimulation (TTS) treatment only (control group) or TTS + neuromuscular electrical stimulation, applied simultaneously. Swallowing function was assessed before and 4 weeks after treatment using the swallow function scoring system (scoring: 0-6 with lower scores indicating greater severity), the penetration-aspiration scale (PAS) (scoring: 1-8 with higher scores indicating increasing aspiration/penetration) and	28 persons completed the study. Median swallowing scores for the control group, on semi-solids consistency, before and after treatment were 3 and 4, and 2 and 4 for the experimental group. Median PAS scores for the control group before and after treatment were 3.5 and 4 (indicating a worsening) and 5.5 and 2.5 for the experimental group. The differences in both scores between the two groups were

	pharyngeal transit time. Semi-solid and liquid consistencies were evaluated.	significant. There was significantly greater improvement in pharyngeal transit time in the experimental group.
Jayasekeran et al. (2010) UK 8 (RCT)	50 acute dysphagic stroke patients were assigned randomly to receive either active or sham pharyngeal electrical stimulation (PES) once daily for 3 days. (n = 28). The primary end point was the reduction of airway aspiration at 2 weeks post intervention assessed using VFS. Additional outcomes included scores on a Dysphagia Severity Rating (DSR) rating scale	Patients who received the active form of PES experienced significantly fewer episodes of aspiration, greater improvement in DSR and remained in hospital for a shorter period of time compared with patients who received sham treatment.
Gallas et al. (2010) France No Score	11 stroke patients with dysphagia lasting greater than 8 weeks received sub mental electrical stimulations for 1 h every day for 5 days (electrical trains: 5 s every minute, 80 Hz). During stimulations patients were asked to swallow one teaspoon of paste or liquid. Swallowing was evaluated before and after treatment using a dysphagia handicap index questionnaire (max score of 120 and VMBS.	The mean score on the dysphagia questionnaire improved over the treatment period (31 vs. 23, p<0.05). On VMBS examination, laryngeal aspiration and pharyngeal residue had decreased significantly and swallowing reaction time increased.
Xia et al. (2011) China 4 (RCT)	120 patients with post-stroke dysphagia were randomly assigned to one of 3 groups: 1) conventional swallowing therapy group, 2) electrical stimulation (ES) with the VitalStim therapy group, and 3) VitalStim therapy plus conventional swallowing therapy group. Treatments with ES were given twice a day for 230 min each, 5 days a week for 4 weeks. Swallowing function was evaluated by using the Standardized Swallowing Assessment (SSA).	SSA scores before and after treatment were: Conventional-40.9 to 30.1, ES-38.7 to 29.6, ES + Conventional-39.5 to 21.4. The scores were significantly greater in the VitalStim therapy plus conventional swallowing training group than in the conventional swallowing training group and VitalStim therapy group, but no significant difference existed between conventional swallowing therapy group and VitalStim therapy group.
Park et al. (2012) Korea 7(RCT)	20 patients with dysphagia that persisted >1 month stroke onset were randomly divided into two groups: those who underwent effortful swallow with infrahyoid motor electrical stimulation (experimental group, n = 10) and effortful swallow with infrahyoid sensory electrical stimulation (control group, n = 10). In the experimental group, electrical stimulation was applied to the skin above the infrahyoid muscle with the current was adjusted until muscle contraction occurred and the hyoid bone was depressed. In the control group, the stimulation intensity was applied just above the sensory threshold. The patients in both groups were then asked to swallow effortfully in order to elevate their hyolaryngeal complex when the stimulation began. A total of 12 sessions of 20 min of training for 4 weeks were performed. Measurements of the extent of hyolaryngeal excursion, the maximal width of the upper esophageal sphincter (UES) opening, and the penetration-aspiration scale before and after training were performed.	In the experimental group, the maximal vertical displacement of the larynx was increased significantly after the intervention. The maximal vertical displacement of the hyoid bone and the maximal width of the UES opening increased but was not statistically significant. There was no increase in the control group. The results of between group differences were not reported.
Kushner et al. (2013) USA	92 patients admitted to inpatient rehabilitation with dysphagia were included. 65 patients received neuromuscular electrical stimulation (NMES) and	The control group had statistically significantly greater baseline FOIS scores compared to the NMES group (z=-2.4; P=0.015). There were

	traditional dysphagia therapy (TDT) while 27 patients received traditional dysphagia therapy alone. TDT, including progressive resistance training, were provided to patients based on their initial clinical assessment and involved 5-6 hourly sessions per week during their stay in inpatient rehabilitation. NMES treatment involved hourly sessions at a pulse rate of 5-120Hz and a pulse duration of 100-300 usecs depending on the patient size/tolerance etc. Outcomes were assessed using the functional oral intake scale (FOIS) before and after treatment.	statistically significant improvements in swallowing function for the NMES group compared to the control group (z = 3.6; P<0.001). Patients in the NMES group were also significantly more likely to have no swallowing restrictions (i.e. have a score of 5-7 on the FOIS), controlled for age, sex, and stroke location (Note: initial FOS was not controlled for in the analysis). No adverse events were reported.

Five RCTs evaluated the potential benefit of electrical stimulation in the rehabilitation of swallowing. The treatment contrasts 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, the use of two co-interventions (ES+ therapy) improved swallowing function compared to either of the two interventions given in isolation (Xia et al. 2011).

Conclusions Regarding the Use of Electrical Stimulation

There is conflicting (Level 4) evidence that electrical stimulation can improve swallowing function post stroke.

15.9.6 Alternative Interventions

In addition to the more conventional interventions, including texture-modified diets and non-oral feeding, several studies have assessed the efficacy of other treatments such as thermal stimulation, acupuncture, antihypertensive agents, antiplatelet agents, and decontamination of the digestive tract (Table 15.28). Transcranial direct current stimulation (tDCS) (Table 15.29) and repetitive transcranial magnetic stimulation (rTMS) (Table 15.30) for the treatment of dysphagia have also started to emerge.

Table 15.28 Effect of Alternative Interventions used in Post-Stroke Dysphagia Treatment

Author, Year Country PEDro Score	Methods	Outcomes
Logemann et al. (1989) USA No Score	The effect of head rotation on swallowing function was evaluated on 5 lateral medullary stroke patients and 14 healthy adults.	Head rotation did not alter the swallowing efficiency of healthy subjects. In stroke patients head rotation improved swallowing "efficiency" from 21 to 50% and increased the diameter of the upper esophageal sphincter from 7.7 to 11.6 mm.
Rosenbek et al. (1991) USA 6 (RCT)	In a crossover ABAB study, 7 patients received a week-long period of thermal application (chilled laryngeal mirror used to stroke the anterior faucial pillar on both sides), followed by 3 cc of water or ice chips, followed by no treatment for one week.	No evidence that treatment with thermal application improved incidence of aspiration, penetration or residuae.
Perez et al. (1998) UK 7 (RCT)	17 patients were randomized to receive 30 mg slow release nifedipine orally or placebo for 28 days. All patients also received treatment by a speech	Patients in the treatment group demonstrated significant improvement in mean pharyngeal transit time and swallowing delay compared to

	therapist.	patients in the control group.
Arai et al. (1998) Japan No Score	16 hypertensive stroke patients with symptomless dysphagia and 10 hypertensive patients without dysphagia and 7 control patients were studied. To observe the occurrence of symptomless dysphagia 1 mL of Technetium Tin Colloid was given during sleep by nasal catheter. Hypertensive patients received an ACE inhibitor.	Symptomless dysphagia improved in 10/16 patients, as assessed by changes in serum substance P concentrations. No details of dosages of ACE inhibitor or length of treatment time were reported.
Rosenbek et al. (1998) USA 5 (RCT)	45 patients were randomized to receive treatment that included rubbing both anterior faucial pillars briskly, 3 or more times with an ice stick. Study Group A:150 trials of tactile-thermal stimulation per week; Study Group B:300 trials per week; Study Group C:450 trials per week; Study Group D:600 trials per week 2 outcomes were assessed at 1 and 2 weeks: Duration of Stage Transition-DST (sec) with intakes of 3 mL and 10 mL liquid; Penetration/Aspiration-P/A with intakes of 3 mL and 10 mL liquid.	Combing all levels of intensity, mean DST was reduced with 3 mL fluid intake at week 2 (1.17 sec, p=0.06). There were no significant improvements in DST using 10 mL fluid. With both 3 and 10 mL boluses, no intensity of treatment was associated with a clinically significant improvement in P/A. score. A statistically significant improvement in mean P/A scores was associated with 150 trials per week at weeks 1 and 2 (3 mL bolus only). Combining all levels of intensities, mean P/A scores were reduced with 3 mL fluid intake at weeks 1 (0.55, p=0.04 and 2 (0.59, p=0.03).
Arai et al. (2003) Japan RCT (insufficient data provided to score-letter to the editor)	51 stroke patients, all with proven silent aspiration (assessed by 1 mL of Technetium Tin Colloid was given during sleep by nasal catheter) were studied. 39 normotensive patients were randomized to receive cabergoline (0.25 mg/day) n=13, amantadine (50 mg/day) n=14, or no active treatment (n=12). The remaining 12 patients were hypertensive and received imidapril (5 mg/day). Treatment lasted for 12 weeks.	Silent aspiration disappeared in 10/13 patients given cabergoline, 10/14 patients given amantadine and 9/12 patients given imidapril and in 1/12 of the control patients. Significant differences were noted between the collective treatment group and no treatment group.
Crary et al. (2004) Florida No Score	25 patients with dysphagia underwent a systematic therapy program. Stroke patients' outcomes were compared to 20 head/neck cancer patients. Sessions were 50 min per day (no weekends) with surface electromyographic (sEMG) biofeedback. Outcome measures included change in functional oral intake, the number of therapy session to discharge, and estimated cost per unit of functional charge.	92% of the stroke patients increased functional oral intake by at least one scale score following therapy. 48% of the stroke patients improved 1 or 2 levels, 20% improved 3 to 5 levels, and 24% improved 6 levels. Of the stroke patents reliant on nonoral feeding pre-therapy, 55% progressed to total oral feeding.
Seki et al. (2005) Japan RCT (insufficient data provided to score-letter to the editor)	32 stroke patients with severe dysphagia were randomized to receive acupuncture 3 x per week x 4 weeks + usual care or to usual care. Swallowing function was assessed by VMBS at baseline and at the end of treatment.	In the intervention group, the swallowing time of water and fluid food were shortened significantly. The incidence of aspiration on 3 food consistencies (water, fluid food and solid food) was reduced significantly in the intervention group, with no corresponding declines in the control group.
Gosney et al. (2006) UK 6 RCT	203 stroke patients were randomized to receive either selective decontamination of the digestive tract (SDD) gel or placebo 4 x daily for 2 weeks (patients with safe swallow) or 3 weeks (unsafe swallow). Outcomes included the incidence of colonization of aerobic gram negative bacilli (AGNB) and septicemia or respiratory tract infections during hospital stay.	58/203 (29%) patients had dysphagia on admission. AGNB was acquired on 2 or more consecutive samples in 6 patients in the treatment group and 11 in the control group. The difference between groups was not statistically significant. Four patients in the treatment group acquired either pneumonia or

		septicemia during the study period compared to 10 in the placebo group (p=0.029). Mortality between groups was similar (9 in treatment group vs. 11 in control group).
Ebihara et al. (2006) Japan 5 (RCT)	105 chronic stroke patients residing in nursing homes were randomized to either a study group, black pepper oil (BPO)(n=35), or one of 2 control groups, lavender oil (LO) (n=35), or distilled water (n=35). Nasal inhalation of 100цL of one of the 3 substances was administered to the nostrils with a paper stick. Subjects received the treatment 1 minute before each meal during the 30-day study period. Latency of the swallowing reflex (LTSR) and the number of swallowing movements were assessed.	Nasal inhalation of BPO shortened LTSR, compared with that of lavender oil and distilled water (P < .030. The number of swallowing movements for 1 minute during the nasal inhalation of BPO increased (P < .001).
Robbins et al. (2007) USA No Score	10 stroke patients (6 acute and 4 chronic) performed an 8-week isometric lingual exercise program by compressing an air-filled bulb between the tongue and the hard palate. This exercise was repeated 10 x, 3 times a day, 3 days a week. Isometric and swallowing lingual pressures, bolus flow parameters, diet, and a dysphagia-specific quality of life questionnaire (QoL) were assessed at baseline, week 4, and week 8.	There was a significant increase in maximum isometric pressure (anterior and posterior tongue) over the study period. There was significant reduction in overall residue for 3 bolus conditions (3 mL effortful swallow, 10 mL liquid and 3 mL liquid). There were significant improvements 3/11 subscales of the QoL questionnaire.
Shimizu et al. (2008) Japan No Score	The pharyngeal transit time (PTT) of 10 elderly subjects with stroke was assessed using VMBS before and after 6 weeks of therapy with 5 mg imidapril. The results were compared with 10 age-matched healthy subjects.	The PTT of control subjects was unchanged from first to second assessment. (2.4 vs. 2.6 sec). The PTT of subjects receiving the ACE inhibitor significantly decreased from baseline to 5 weeks (2.5 vs. 1.6 sec, p<0.01). Abnormalities in the oral and esophageal phases were not altered by treatment.
Terre & Mearin (2012) Spain No Score	47 patients (31 stroke, 16 traumatic brain injury) with confirmed aspiration and 25 controls without aspiration (14 stroke, 11 TBI) swallowed thickened fluids of differing volumes in random order (either the normal anatomical or the chin down position) during VMBS examination. Various swallowing parameters were evaluated.	During the chin-down posture, 55% of patients avoided aspiration (40% pre-swallow aspiration and 60% aspiration during swallow). Fifty-one percent of patients had silent aspiration; of these, 48% persisted with aspiration while in the chin-down posture. A statistically significant relationship was found between the existence of pharyngeal residue, cricopharyngeal dysfunction, pharyngeal delay time and bolus volume with the persistence of aspiration. The chin-down posture did not change swallow biomechanics in patients without aspiration.
Feng et al. (2012) China 6 (RCT)	122 patients were randomized to either treatment (n=61) or control (n=61) groups. Both treatment and control patients were provided usual care (maintaining vitals and electrolytes, acupuncture therapy, rehabilitation training and ice stimulation). The treatment group received Tongyan Spray 30 min before each meal, 3x per day for 28 days (each dose consisted of 3 sprays – middle, left and right side of the pharynx). The control group received a comparable treatment protocol only using a placebo	Patients in the intervention group experienced statistically significant improvement in SSA score compared to controls (-6.45±2.53 vs. -5.02±2.42; P=0.002). Regardless of grade of swallowing function severity, all patients in the intervention group experienced statistically significant improvements in SSA score compared to controls (Grade 1: -5.50±1.87 vs. -4.25±1.77; P=0.045. Grade 2-3: -7.00±2.72 vs. -5.30±2.58; P=0.005).

Author, Year Country PEDro Score	Methods	Outcomes
	spray and having it applied externally. Standard Swallowing Assessment Scale (SSA) was used to assess outcomes after 28 days of treatment.	
Nakamura & Fujishima (2013) Japan No Score	24 patients were included in a cross over trial consisting of 4 rounds of swallowing commands alternating between a swallow command after ice massage, and a swallow command after no ice massage. The starting condition (ice massage first or no ice massage first) for each patient was randomized. The ice massage consisted of 10 seconds of light application of an ice stick around key areas of the oral cavity (posterior tongue, tongue base, velum, posterior pharyngeal wall). For patients who were able to swallow after each of the 4 rounds, the time elapsed from the swallow command to when the larynx reached the highest position on the VFES was recorded. For those patients who were unable to swallow all 4 rounds, the number of times the patient successfully swallowed after each condition was enumerated.	10 patients were unable to swallow in all 4 rounds. For those patients, a greater number of swallows were completed after ice massage vs. after no ice massage (1.40 ± 0.72 vs. 0.20 ± 0.32; P=0.0413). For the 14 patients who swallowed in all 4 rounds, there was a statistically significant shorter time to swallow after receiving ice massage vs. after no ice massage (1.55 ± 0.42 vs. 2.17 ± 1.53; t=2.16; P=0.00366). The swallowing time, however, was dependent on lesion location. Those individuals with nuclear lesions did not experience statistically significant improvements in swallow time compared to those individuals with supranuclear lesions.
Osawa et al. (2013) Japan No Score	189 patients admitted to a rehaibltiation department and considered candidates for cilostazol were included for retrospective chart review. Data extracted from the charts included age, stroke type, CNS score, MMSE score, FIM score, discharge destination, oral intake at discharge, presense of aspriation pneumonia and the use of ciostazol.	Aspiration pneumonia was detected in 27 patients (14.3%). There was a statistically signifcantly lower incidence of aspiration pneumonia in patients who received cilostazol compared to patients who did not receive cilostazol (3/48 vs. 24/141; P=0.476). No other chart extracted factors were significantly associated with its use.
Theurer et al. (2013) Canada No Score	8 patients diagnosed wtih dysphagia following stroke were included. All individuals received 5 air-pulse trains, each of which lasted 5 minutes in duration. Air pulses were directed to oropharyngeal region using a mouthpiece positioned along the alveolar ridge of the mandible. Unilateral and bilateral air-pulse applications were made as well as sham applications for 5 of the 8 patients. Swallowing rates (swallows per minute) were compared before and after the administration air-pulses using standard deviation bands (2SD) as thresholds for significance.	4 (50%) of subjects were found to have significantly greater swallowing rates following the administration of air pulses. These subjects had a greater mean baseline swallowing rate compared to subjects who experienced no benefits.

Table 15.29 transcranial direct current stimultation (tDCS)

Author, Year Country PEDro Score	Methods	Outcomes
Kumar et al. (2011) USA 7 (RCT)	14 patients within 1-7 days of unilateral hemispheric infarction were randomized to receive anodal transcranial direct current stimulation (tDCS) versus sham stimulation to the **unaffected hemisphere** over 5 consecutive days with concurrent standardized swallowing maneuvers. The Dysphagia Outcome and Severity scale (scale range of 1-7) was assessed before	Patients who received anodal tDCS gained more points on the DOSS (2.60 vs. 1.25, p=0.019) after controlling for the effects of stroke and dysphagia severity, age and time from stroke onset. Six out 7 (86%) patients in tDCS group gained at least 2 points of improvement compared with 3 out 7 (43%) patients in the

	and after treatment.	sham group (P=0.107).
Yang et al. (2012) South Korea 8 (RCT)	16 patients were randomized to either active anodal transcranial direct current stimulation (tDCS) (n=9) or sham treatment (n=7). Treatment lasted 30 min, 5x/week, for 2 weeks. The intervention group received anodal tDCS (increased gradually to 1 mA over several seconds) over the **affected pharyngeal motor cortex** and conventional swallowing training for the first 20 min of each session. The last 10 minutes of each session involved swallowing training alone. Treatment was comparable in the control group, but the tDCS lasted only 30 seconds. Functional dysphagia scale (FDS), oral transit time (OTT), pharyngeal transit time (PTT) and total transit time (TTT) were measured before, immediately after and at 3 months follow up.	Patients receiving anodal tDCS experienced statistically significant improvements in swallowing function based on the change in FDS score from pre intervention to 3 months post intervention when compared to controls (13.00 ± 12.18, vs. 9.83 ±7.06; P=0.041). There were no statistically significant changes in OTT, PTT or TTT between the tDCS group and control group.
Shigematsu et al. (2013) Japan 9 (RCT)	20 patients were randomized to either active anodal transcranial direct current stimulation (tDCS) (n=10) or sham treatment (n=10). Treatment lasted 20 min, 5x/week for 2 weeks. The intervention group received anodal tDCS over the **affected pharyngeal motor cortex** (with the cathode placed on the opposite hemisphere in the supraorbital region) and conventional swallowing therapy. Treatment was comparable in the control group, but the tDCS lasted only 40 seconds. Dysphagia Outcome and Severity Scale (DOSS) was assessed pre and post intervention and at 1 month follow up.	Patients receiving anodal tDCS experienced statistically significant improvements in swallowing function based on DOSS score from pre intervention to 1 month post intervention compared to controls (1.9±0.7 pre intervention to 4.7±0.9 1 month post vs. 2.3±1.0 pre intervention to 3.5±0.9 post intervention; P=0.007).

Table 15.30 repetitive Transcranial Magnetic Stimulation (rTMS)

Author, Year Country PEDro Score	Methods	Outcomes
Khedr et al. (2009) Egypt 6 (RCT)	26 patients with post-stroke dysphagia due to single hemispheric stroke were randomly allocated to receive real (n = 14) or sham (n = 12) rTMS of the affected motor cortex. Each patient received a total of 300 rTMS pulses at an intensity of 120% hand motor threshold for five consecutive days. Clinical ratings of dysphagia were assessed using the Dysphagic Outcome and Severity Scale before and after the last session and then again after 1 and 2 months. Scores ranged from 1 (no dysphagia) to IV (obvious dysphagia precluding oral feeding). All subjects received standard medical and physical therapy.	At baseline the mean dysphagia score for the control group was 3.7 vs. 3.4 for the real rTMS group. By 2 months the real rTMS groups' mean score was approximately 1.0 vs. 3.0 for the control group. There was a significant time x group interaction.
Khedr & Abo-Elfetoh (2010) Egypt 6 (RCT)	22 patients with acute ischemic stroke with lateral medullary syndrome or brainstem infarction severe bulbar manifestation were randomly allocated to receive active (n=11) or sham (n=11) repetitive transcranial magnetic stimulation (rTMS) of the esophageal motor cortex. Each patient received 300 rTMS pulses at 3 Hz and an intensity of 130% resting	Among patients with lateral medullary there were significant improvements in dysphagia scores and BI scores in the active rTMS group compared with the sham group that were maintained over the study period. Among patients with other types of brainstem infarcts who received rTMS, there was significant

	motor threshold to each hemisphere for five consecutive days. Outcomes were assessed before and immediately after the last session, and then again after 1 and 2 months using a 4-point dysphagia grading scale, NIHSS, BI and the Hemiplegic Stroke Scale.	improvement in dysphagia scale scores compared with sham treatment.
Park et al. (2013) South Korea 7 (RCT)	18 patients were randomized to either active repetitive transcranial magnetic stimulation (rTMS) (n=9) or sham treatment (n=9). Treatment lasted 10 min, 5x/week for 2 weeks. Each session involved 10 rounds of 5-Hz stimulation for 10 seconds each repeated every minute. rTMS was applied to the non-affected pharyngeal motor cortex. A 90 degree coil tilt was used in the control group to replicate treatment conditions but produced no motor cortex stimulation. Videofluoroscopic dysphagia scale (VDS) and Penetration-Aspiration Scale (PAS) scores were assessed at pre and post intervention and at 2 weeks follow up.	Patients receiving rTMS experienced statistically significant improvements in swallowing function both post-intervention and at 2 weeks follow up on the VDS (33.6 ± 12.1 at baseline to 25.3 ± 9.8 post intervention and at 2 week follow up; $P<0.05$). When VDS scores were assessed according to the pharyngeal and oral phase of swallowing, results were only significantly improved in the pharyngeal phase. PAS scores were also statistically significantly lower in the intervention group (3.42 ± 2.32 pre intervention to 1.93 ± 1.52 post intervention and 1.37 ± 0.87 at 2 week follow up; $P<0.05$). There were no statistically significant improvements in VDS or PAS score in the control group.

Discussion

The use of medications to improve swallowing function was assessed in three small RCTs (Arai et al. 2003; Kobayashi et al. 1996; Perez et al. 1998). Perez et al. (1998) reported that Nifedipine, a calcium channel blocker improved pharyngeal transit time and swallow delay. The mechanism through which the benefits were achieved is uncertain although the authors speculated that it might be mediated by the reduction of esophageal spasm, through the action of dihydropyridines on the calcium channels, of nonvascular smooth muscle. Kobayashi et al. (1996) reported improved latency of response in a small crossover designed study evaluating levodopa. Arai et al. (2003) evaluated the effectiveness of the dopamine agonists, cabergoline, reported to have fewer side effects than levodopa, and the drug Amantadine, an antidyskinetic and reported a significant reduction in the incidence of silent aspiration among normotensive patients with stroke, compared to a no drug control condition.

Among patients with known hypertension, the angiotensin-converting enzyme (ACE) imidaril hypochloride also reduced the incidence of silent aspiration compared to control. Shimizu et al. (2008) also evaluated the effect of the ACE inhibitor, imidapril in a small group of elderly stroke subjects. The use of an ACE inhibitor was associated with a reduction in pharyngeal transit times. ACE inhibitors are believed to confer benefit through an increase in serum substance P concentration. A meta-analysis assessing the impact of ACE inhibitors in preventing pneumonia included the results of 5 cohort studies with 8,693 patients. ACE inhibitors were found to offer a protective effect overall (Relative Risk 0.61; 95% CI 0.51 to 0.75). The number needed to treat was 34.4 patients (95% CI 25.9 to 50.6) Cilostazol, an antiplatelet agent, is also believed to have effects on substance P concentrations in the brain. A retrospective study of patients receiving care in a rehabilitation ward for stroke found that the relative risk of aspiration pneumonia was lower in patients who received cilostazol treatment compared to those who did not (Osawa et al. 2013).

Two studies authored by Rosenbek and colleagues evaluated the effectiveness of cold stimulus to improve specific aspects of the swallowing mechanism (Rosenbek et al. 1991; Rosenbek et al. 1998). The earlier study evaluating 7 patients using a crossover design, failed to demonstrate a significant benefit of the treatment. A second, slightly larger study, evaluated the effect of four increasing intensities of tactile thermal application. The study design did not include a control group. The results did not favour a single level of intensity of treatment. In the absence of a control group, conclusions regarding the effectiveness of these treatments could not be drawn. A study by Nakamura et al. (2013) on ice massage found statistically significant improvements in dysphagia scores.

The use of antimicrobial agents to reduce the bacterial load in the digestive tract of stroke patients, in an effort to reduce the incidence of aspiration pneumonia was assessed in a single RCT (Gosney et al. 2006). Treatment with the antimicrobial gel removed the presence of a variety of aerobic gram-negative bacilli, which resulted in a decreased incidence of septicemia and pneumonia.

Ebihara et al. (2006) provided preliminary evidence that inhalation of black pepper oil can help to prevent the development of aspiration pneumonia. The authors speculated that the insular cortex plays a role in both dysphagia and appetite stimulation, and since black pepper oil is an appetite stimulant and increases blood flow to this area, it might be an effective approach to the treatment of dysphagia.

Although various compensatory manoeuvres such as the head turn and the chin down position are used clinically as compensatory strategies to reduce the risk of aspiration, there is very little evidence to support their use. Terre & Mearin demonstrated that aspiration was prevented in only 55% of patients who were known aspirators (Terre & Mearin 2012). Only 52% of silent aspirators avoided aspiration. The chin down position appeared to be less effective when patients presented with greater severity of dysphagia.

Traditional Chinese Medicine, including tongyan spray and acupuncture, have also been studied for their effectiveness as dysphagia interventions (Feng et al. 2012; Seki et al. 2005). One Cochrane review assessing acupuncture in the acute stage of stroke (30 days post) found only one trial meeting inclusion criteria (Xie et al. 2008). Two reviews since have identified a much larger number of studies (Long & Wu 2012; Wong et al. 2012). However, differing inclusion/exclusion criteria are likely to explain these results. Wong and colleagues (2012) identified 9 trials that compared the effects of acupuncture (and conventional therapy) to conventional therapy alone. The included RCTs had to be eligible for evaluation using the PEDro tool. All studies showed statistically significant improvements in outcomes with the use of acupuncture (Wong et al. 2012). Long & Wu (2012) included 72 RCTs in their meta-analysis, but had broader inclusion criteria compared to Wong et al. (2012). All studies that compared acupuncture treatment to any therapy (not just conventional therapy) were included. The odds of an improved outcome were statistically significantly greater in the acupuncture group compared to the non-acupuncture group (OR 5.17; 95% CI 4.18 to 6.38). All studies included must have been eligible for evaluation using the Jadad scale (Long & Wu 2012).

The results of studies using an RCT to evaluate an alternative intervention are presented in table 15.31.

Table 15.31 Summary of RCTs Evaluating an Alternative Interventions

Author, Year PEDro Score	N	Intervention	Main Outcome(s) Result
Rosenbek et al. (1991)(6)	7	Thermal stimulation	-
Rosenbek et al. (1998)(5)	45		-

Perez et al. (1998)(7)	17	Nifedipine	+
Gosney et al. (2006)(6)	203	SDD (selective decontamination of the digestive tract)	+
Ebihara et al. (2006)(5)	105	Black pepper oil	+
Feng et al. (2012)	122	Tongyan Spray	+
Khedr et al. (2009)(6)	26	Transcranial magnetic stimulation	+
Khedr & Abo-Elfetoh (2010)(6)	22		+
Park et al. (2013)	18		+
Kumar et al. (2011)(7)	14	Transcranial direct current stimulation	+
Yang et al. (2012)	16		+
Shigematsu et al. (2013)	20		+
Terre & Mearin (*2012)	47	Chin down position	-

+ evidence of benefit when compared to control condition
- no evidence of benefit when compared to control condition

Conclusions Regarding Alternative Interventions in Dysphagia

There is strong (Level 1a) evidence that repetitive Transcranial Magnetic Stimulation improves swallowing function post stroke.

There is strong (Level 1a) evidence that transcranial Direct Current Stimulation improves swallowing function post stroke.

There is moderate (Level 1b) evidence that Nifedipine and black pepper oil can be used to improve specific aspects of swallowing following stroke.

There is moderate (Level 1b) evidence that selective decontamination of the digestive tract can help to reduce the incidence of pneumonia.

There is strong (Level 1a) evidence that thermal stimulation does not improve swallowing function post stroke.

There is limited (Level 2) evidence that head rotation, lingual exercises and EMG treatment can be used to improve swallowing function post stroke.

There is limited evidence that the chin down position prevents aspiration in approximately 50% of patients who are known aspirators.

A variety of alternative treatments can be used to improve swallowing function post stroke.

15.10 Summary

1. *The incidence of dysphagia appears to be quite high following acute stroke, with between one-third to two-thirds of all stroke patients affected.*

2. *VMBS studies are the "gold standard" for diagnosing dysphagia and aspiration.*

3. *The incidence of aspiration in the acute phase of stroke varies from 21-42% and decreases to less than 12% by 3 months post stroke. Between one-third and one-half of patients who aspirate following stroke are silent aspirators.*

4. *Aspiration appears to be associated with an increase in the incidence of pneumonia. The risk of developing pneumonia appears to be proportional to the severity of aspiration.*

5. *There is limited (Level 2) evidence that dysphagia screening protocols can reduce the incidence of pneumonia.*

6. *There is consensus (Level 3) opinion that acute stroke survivors should be NPO until swallowing ability has been determined.*

7. *There is consensus (Level 3) opinion that a trained assessor should screen all acute stroke survivors for swallowing difficulties.*

8. *There is consensus (Level 3) opinion that a speech and language pathologist should assess all stroke survivors who fail swallowing screening and identify the appropriate course of treatment.*

9. *There is consensus (Level 3) opinion that an individual trained in low-risk feeding strategies should provide feeding assistance or supervision to all stroke survivors.*

10. *There is consensus (Level 3) opinion that a dietician should assess the nutrition and hydration status of all stroke patients who fail a swallowing screening.*

11. *There is consensus (Level 3) opinion that dysphagic stroke patients typically require diets with modified food and liquid textures.*

12. *For patients who require assistance to feed, there is a consensus (Level 3) opinion that low-risk feeding strategies by trained personnel should be employed.*

13. *There is consensus (Level 3) opinion that for patients on modified diets that a dietitian should be consulted to ensure that the modified diet is nutritionally adequate and appropriate, and to consult the stroke survivor or substitute decision-maker, to ensure that the modified diet is as appealing as possible.*

14. *There is limited (Level 2) evidence that dysphagia diets reduce the incidence of aspiration pneumonia. There is moderate (Level 1b) evidence that thickened fluids result*

in fewer episodes of aspiration and penetration compared with thin fluids among dysphagic individuals following stroke.

15. *There is limited (Level 2) evidence that patients requiring texture-modified diets including thickened fluids can safely consume thin fluids between meals without increasing their risk of pneumonia.*

16. *There is moderate (Level 1b) evidence that Nifedipine improves specific aspects of swallowing function following stroke.*

17. *There is limited (Level 2) evidence that head rotation can improve swallowing function in lateral medullary stroke patients.*

18. *There is moderate (Level 1b) evidence that thermal stimulation does not improve swallowing mechanics post stroke.*

19. *There is moderate (Level 1b) evidence that a short course of formal dysphagia therapy does not alter clinical outcomes. Based on the result from a single RCT, there is moderate (Level 1b) evidence that a one-month dysphagia intervention program does not improve the likelihood of returning to a normal diet by six months. However, there is also moderate (Level 1b) evidence that such a program may reduce the likelihood of chest infections and death or institutionalization.*

20. *There is consensus (Level 3) opinion that enteral tube feeding be used in stroke patients at high risk of aspiration or for those who cannot meet their nutritional need orally. Enteral feeding should be considered after a stroke survivor has been NPO for 48 hours.*

21. *There is consensus (Level 3) opinion that if dysphagia is severe and expected to last more than 6 weeks, a gastrostomy or jejunostomy feeding tube may be indicated.*

22. *There is limited (Level 2) evidence that enteral feeding tube can deliver adequate nutrition and hydration to stroke survivors.*

23. *There is strong (Level 1a) evidence that intragastric feeding devices are associated with fewer mechanical failures compared to nasogastric feeding tubes.*

24. *Although enteral feeding for dysphagic stroke patients is a well-established practice, there is only moderate (Level 1b) evidence that its use reduces the risk of pneumonia. There is conflicting (Level 4) evidence that nasogastric tubes reduce the risk of pneumonia. There is moderate (Level 1b) evidence that the risk of developing pneumonia is higher among ventilated patients fed by a naso-gastric tube compared with a gastrostomy tube.*

25. *Based on the results from one large, international trial, there is moderate (Level 1b) evidence that the type of feeding tube (nasogastric or gastro-enteric) does not affect the odds of death or the combined outcome of death or poor functional outcome.*

26. *There is moderate (Level 1b) evidence that securing naso-gastric tubes with a tether-like device reduces the number of dislodged tubes and increases the amount of required feed and fluids that patients receive.*

27. *There is moderate (Level 1b) evidence that Nifedipine and black pepper oil can be used to improve specific aspects of swallowing following stroke.*

28. *There is strong (Level 1a) evidence that transcranial magnetic stimulation improves swallowing function post stroke.*

29. *There is moderate (Level 1b) evidence that selective decontamination of the digestive tract can help to reduce the incidence of pneumonia.*

30. *There is strong (Level 1a) evidence that thermal stimulation does not improve swallowing function post stroke.*

31. *There is conflicting (Level 4) evidence that electrical stimulation can improve swallowing function post stroke.*

32. *There is limited evidence that the chin down position prevents aspiration in approximately 50% of patients who are known aspirators.*

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