MONITORING NATURAL PROGRESSION OF DYSPHAGIC SYMPTOMS IN STROKE

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Abstract

Swallowing difficulties after acute stroke are common. Clinical bedside assessments are used frequently to detect acute dysphagia. Published studies which have assessed the natural history of swallowing using bedside assessments have only observed swallowing for a short period of time. The purpose of this investigation was to monitor the natural progression of dysphagic symptoms in stroke over three month using a clinical assessment. 26 patients consecutively admitted to the regional public hospital were assessed using a clinical assessment consisting of cranial nerve exam, observation of oral intake, water swallow test and inhalation cough challenge. The assessment was implemented within 72 hours post admission and then after one week, three weeks and three months. For this exploratory study, descriptive statistics were used to explore the data set. The results confirm that dysphagia after stroke is common and that there are improvements within three months.

1 Chapter

Introduction / Literature Review

1.1 Normal swallowing

Swallowing is a complex physiological process that transports food, fluid or saliva from the mouth to the stomach. It is considered to consist of both volitional and involuntary activity. For descriptive purpose swallowing is usually divided into phases. Contemporary descriptions vary from two up to six different phases. Most authors describe three phases: oral, pharyngeal and esophageal (Bass & Morrell, 1984; Perlman & Christensen, 1997). Leopold (1997) first recognized the importance of the pre-oral factors related to dysphagia. To take this factor into account swallowing is divided into four phases in this paper: pre-oral, oral, pharyngeal and esophageal phase. A brief overview of peripheral and neural control of swallowing follows, with particular focus on muscular components and their innervations, which forms an essential part of the topic of this project.

1.1.1 Overview of Peripheral Control of Swallowing

Muscular components and innervations patterns

The pre-oral phase is associated with preparation for ingestion. The approaching bolus gives visual and olfactory information which can initiate salivary flow and the adduction of the vocal folds, especially with a liquid bolus (Leopold & Kagel, 1997). Depending on the stimulus, the three salivary glands (parotid gland, CN9; submandibular gland and sublingual gland, CN7) are activated.

During the oral phase food or liquid is taken into the mouth and is prepared for swallowing (Perlman & Christensen, 1997). In this phase the muscles of mastication (masseter, temporalis, lateral and external pterygoid, anterior belly of digastric and geniohyoid), innervated by the mandibular branch of the trigeminal nerve (CN5) and the facial musculature (orbicularis oris and buccinators) supplied by the facial nerve (CN7) play an important role (Bass & Morrell, 1984).

When food or liquid is placed in the oral cavity, the lips close to keep the bolus in the mouth and inhibit anterior spillage. The major action of the oral phase involves tongue movement (Dodds, 1989). The intrinsic muscles of the tongue are innervated by the hypoglossus (CN 12) and move solid or semisolid food within the oral cavity, where it is chewed and mixed with saliva. The muscles of mastication contribute to chewing as well (Bass & Morrell, 1984). The buccinator flattens the cheeks and holds the bolus in contact with the teeth while sensory nerve fibres monitor the progress on bolus breakdown. Sensory input in the oral cavity is provided by the trigeminal (CN5, facial (CN7) and glossopharyngeal (CN9) nerves which feed straight to the NTS (nucleus tractus solitarius). The mandibular branch of CN5 provides sensory innervations for the lower lip and chin, the teeth of the mandible, the oral mucosa of the cheeks and floor of mouth, and the anterior two thirds of the tongue. The sensory input of the taste buds from the anterior two thirds of the tongue, the soft palate, and the adjacent pharyngeal wall are supplied by CN7. The sensory components of CN9 innervate the mucosa and the taste buds of the posterior part of the tongue, the mucosa of the tonsils and the upper pharynx.

The extrinsic muscles of the tongue – genioglossus, hyoglossus, and styloglossus muscles– supplied by the hypoglossal nerve (CN 12) and palatoglossus –supplied by pharyngeal plexus (PP) position the tongue in the oral cavity. The base of tongue approximates the soft palate to contain the bolus orally (Logemann, 1983). Glossopalatal approximation is mainly caused by the palatoglossus (PP) elevating and approaching the palate but several other muscles are involved (styloglossus CN12, tensor veli palatini PP, posterior belly of digastric CN7, and stylohyoid CN7).

When the food is sufficiently manipulated, it is generally formed into a cohesive bolus and positioned on the top of the anterior tongue for transport. The lips and the buccal muscles contract while glossopalatal approximation relaxes to allow the base of tongue to drop. The tongue elevates by contracting styloglossus, and rolls back in peristaltic motion, which pushes the bolus in the pharynx. The contraction of the hyoglossus and geniohyoid depress the base of tongue which triggers activation of muscle spindle receptors embedded in the base of tongue. The bolus leaving the oral cavity triggers sensory receptors at the vertical ramus of the mandible, which are supplied by the glossopharyngeal nerve (CN9). Coincidently the contraction of the musculus levator veli palatine, supplied by the pharyngeal plexus (PP, consisting of fibres from glossopharyngeus and vagus), lifts the velum and closes the nasopharynx (Perlman & Christensen, 1997).

During the pharyngeal phase the bolus is moved into the upper esophagus. There are many motions which occur during this process, all of which happen in rapid succession (Dodds, 1989). The pharyngeal swallow starts with triggering the swallowing response (Logemann, 1983). The tongue pushes the bolus further back to approximate the posterior pharyngeal wall, providing initial pressure on the bolus. The hyoid is moved up and forward by the suprahyoid musculature and strap muscles which are innervated by the trigeminal (CN 5), facial (CN 7), and ansa cervicalis (AC). The geniohyoid (AC), the mylohyoid (CN 5) and the anterior belly of digastric (CN 5) work together to move the hyolaryngeal mechanismen anteriorly. Superior hyolaryngeal excursion is executed by the stylohyoid (CN7) and the posterior belly of digastic (CN 7) (Bosma, Donner, Tanaka, & Robertson, 1986).

Concurrently, the pharyngeal constrictors contract in a descending wave and shorten the pharynx. The forward movement of the hyoid facilitates epiglottic deflection, which guides the bolus towards the pyriform sinuses and protects the airway. The airway is protected by four additional mechanisms: the vocal folds close, the ventricular folds close, the arytenoids approximate and fold over the folds, and the quadrangular membrane compresses (Broussard, 2000; Perlman & Christensen, 1997).

Contraction of pharyngeal constrictors, innervated by the pharyngeal plexus, assists in transporting the bolus through the lower pharynx and the cricopharyngeus muscle (CN 10), or upper esophageal sphincter (UES), which relaxes to let the bolus enter the esophagus. The cricopharyngeus relaxes the hyolaryngeal complex moves superiorly and anteriorly to pull it open. Lower pressure in the esophagus helps to pull the bolus down. As soon as the bolus has passed the UES, the cricoesophageus muscle contracts actively.

The esophageal phase starts when the bolus passes the UES. The esophagus is a muscular tube consisting of inner bandlike and an outer longitudinal musculature. The esophagus enlarges when the longitudinal muscles contract. This elongation triggers subsequent contraction of the bandlike horizontal muscle fibres. These contractions create a peristaltic wave which transports the bolus to the stomach.

1.1.2 Overview of Central Control of Swallowing

According to Wylie, 1989 four main structures are involved in neural control of swallowing: efferent motor fibres of the cranial nerves and ansa cervicalis, afferent sensory fibres contained in the cranial nerves, cerebral and midbrain fibres synapsing in the swallowing centres of the brain stem, and the paired swallowing centres in the brainstem. Afferent cranial nerve fibres – trigeminal, glossopharyngeal and vagus nerves – transmit sensory input from the oropharyngeal and the esophageal tract to the NTS (Dodds, 1989).

The swallowing centres in the brain stem then eliciting the swallowing response and coordinate the act of swallowing (Miller, Bieger, & Conklin, 1997). Cortical input contributes to adapt accordingly and alter the swallow (Hamdy et al., 1997).

The motor and sensory mechanisms of swallowing are controlled by a complex organisation of elements in the brain, but the intricate details of the central swallowing have not been delineated.

1.1.2.1 Brain stem mechanism

Miller (1997) describes two neurons in the brainstem that are primarily involved in swallowing: the nucleus tractus solitarius (NTS) and the nucleus amibguus (NA). These regions are represented on both sides and are considered to be interconnected. Miller highlights that swallowing is elicited by sensory input (Miller, Bieger, & Conklin, 1997). The stimulus must irritate nerve fibres which synapse in the NTS. The superior laryngeal nerve (SLN), which is a part of the vagus nerve afferently, innervates the sensory mucous membranes of the pharynx and larynx. This provides an effective stimulus to elicit a swallow. The NTS gets sensory input from the afferent fibres of the glossopharyngeal and vagus with some contribution by the trigeminal and facial nerve (Dodds, 1989). When the NTS gets proper afferent information, it responds with a motor plan and triggers a swallow.

The primary nucleus for the efferent motor fibres of the glossopharyngeal, vagus and spinal accessory nerves is the nucleus ambiguus. The NA has considerable connections to the motor nuclei of the hypoglossal, facial and trigeminal nerves.

1.1.2.2 Cortex

There is emerging evidence from various studies using electrophysiology and clinical methods that the cerebral cortex plays an important role in regulating swallowing (Ertekin & Aydogdu, 2003; Martin, Goodyear, Gati, & Menon, 2001; Zald & Pardo, 1999). The majority of swallows in humans occur unconsciously but swallowing can be elicited volitionally. Cortical mapping studies have shown that multiple cortical and subcortical areas are activated during swallowing (Zald & Pardo, 1999). The findings of Martin (2001) suggest the cerebral cortex is involved in even highly unconscious saliva swallows. While the involvement of the brain stem in swallowing is well documented in the literature, the role of the cortex is not fully clear.

1.2 Dysphagia

Dysphagia is a medical term defined as "difficulty in swallowing." It derives from the Greek root "*dys*", meaning difficulty or disorder, and "*phagia*", meaning "to eat". Dysphagia suggests difficulty in the passage of solids or liquids from the mouth to the stomach that can result in food entering the airway.

Difficulties in each of the described phases can result in dysphagia (Massey & Shaker, 1997). Swallowing difficulties are often described by symptomatology like aspiration or penetration. Still it is important to differentiate between symptoms and the underlying neuromuscular dysfunction (Logemann, 1983).

Dysphagia can occur in all age groups, resulting from congenital abnormalities, structural damage, and/or medical conditions (Logemann, 1983). The reported incidence of dysphagia is high in the elderly, in stroke patients and in patients who are admitted to acute care hospitals or chronic care facilities (Marik & Kaplan, 2003). Acknowledging that the major causes of dysphagia include head and neck cancer and progressive neurologic diseases like Parkinson's disease, multiple sclerosis, or amyotrophic lateral sclerosis, the high rate of dysphagia in the elderly population is not surprising (Logemann, 1983).

1.3 Stroke and Dysphagia

According to the World Health Organisation (WHO), 15 million people suffer a stroke worldwide every year. Stroke is the third most common source of mortality in New Zealand (Ministry of Health, 2002/2003). Dysphagia post-stroke is frequently documented. Swallowing physiology can be affected by cerebral, cerebellar or brain stem stroke (Martino et al., 2005). Dysphagia is more likely after brainstem strokes but cortical strokes are more common and can also cause dysphagia (Buchholz & Robbins, 1997; Groher, 1984).

Dysphagia presents in 40 to 70% of all stroke patients. In acute stroke, dysphagia is a marker of poor prognosis, increasing the risk of chest infection, malnutrition, persistent disability, prolonged hospital stay, institutionalization on discharge and mortality (Gordon, Hewer, & Wade, 1987; Hinds & Wiles, 1998; Kidd, Lawson, Nesbitt, & Macmahon, 1993; Mann, Hankey, & Cameron, 1999; Ramsey, Smithard, & Kalra, 2003; Smithard et al., 1997). Although dysphagia can resolve spontaneously in some patients within an average of 8.5 days, 10 to 30% continue to exhibit chronic swallowing difficulties with aspiration (Smithard et al., 1997).

Aspiration of food and fluid is a major problem associated with dysphagia and affects 40 to 50% of all dysphagic stroke patients (Mari et al., 1997; Marik & Kaplan, 2003). Aspiration increases the risk of developing complications, such as pneumonia. The risk of developing pneumonia is seven times greater in stroke patients who aspirate, as compared to those who do not (Lim et al., 2001). Aspiration pneumonia is the most common form of hospital-acquired pneumonia among adults and is described as an important factor in prolonging the length of hospitalisation, as well as increasing morbidity and mortality (Barer, 1989; Gordon, Hewer, & Wade, 1987; Kidd, Lawson, Nesbitt, & Macmahon, 1993).

Regarding the severity of the consequences of aspiration, the accurate detection of those patients who are at risk for aspiration has become a main focus of many diagnostic tools. Dysphagia is often defined as aspiration on VFSS. But aspiration is only a consequence of a disordered swallow (Martino, Pron, & Diamant, 2000). Patents are most likely to be dysphagic without aspirating. It has been emphasised by recent publications that assessments which are only sensitive to aspiration do not provide enough information about disordered swallowing physiology (Daniels et al., 2006; McCullough et al., 2005). It is not an appropriate solution to keep those people who are at risk of aspiration with no oral intake (nil by mouth) (Perry & Love, 2001). It is essential to get a wider range of information about the swallowing physiology and the patients limitations and strengths to plan a suitable treatment for safe and pleasurable ingestion (McCullough, Wertz, & Rosenbek, 2001).

1.4 Identification of Dysphagia

Swallowing disorders are generally assessed using a clinical examination or instrumental techniques. The incidence of dysphagia varies depending on the kind of assessment used, because every approach provides different information (Singh & Hamdy, 2006). Instrumental techniques, like Videofluoroscopic Swallowing Study (VFSS) or Fiberoptic Endoscopic Examination of Swallowing (FEES), are considered to be objective tools to assess swallowing function and aspiration. VFSS is regarded as the current gold standard in identifying dysphagia (Horner & Massey, 1988; Kidd, Lawson, Nesbitt, & Macmahon, 1993; McCullough et al., 2005; McCullough, Wertz, Rosenbek, & Dinneen, 1999; McCullough et al., 2001; Perry & Love, 2001; Ramsey, Smithard, & Kalra, 2003; Singh & Hamdy, 2006; Tohara, Saitoh, Mays, Kuhlemeier, & Palmer, 2003).

However, instrumental techniques are often difficult to obtain due to patient clinical status or limited availability (McCullough et al., 2005; Tohara, Saitoh, Mays, Kuhlemeier, & Palmer, 2003). Therefore, the clinical assessment is most frequently used in clinical practice to screen for signs of dysphagia or aspiration (Mann & Hankey, 2001; Singh & Hamdy, 2006).

1.5 Clinical assessment

The clinical assessment is the most commonly used swallowing evaluation and usually consists of an assortment of different examination techniques (Ramsey, Smithard, & Kalra, 2003; Schulze-Delrieu & Miller, 1997). A clinical assessment typically includes acquiring medical information about the patient, observation of oral intake and an examination of oromotor function (McCullough, Wertz, Rosenbek, & Dinneen, 1999; Nishiwaki et al., 2005; Schulze-Delrieu & Miller, 1997).

The findings of the clinical evaluation enable assumptions regarding impairment of oral, pharyngeal and laryngeal swallow physiology. However, it does not provide an opportunity to directly observe the physiology of swallowing at any time (McCullough et al., 2005). Additionally, many of the components of a clinical assessment are nonvalidated and based on subjective clinical observation. The clinical assessment is criticised for a lack of sensitivity and specifity in detecting aspiration (Leder & Espinosa, 2002; Lim et al., 2001; Logemann, 1983; Mann, 2002; Martino, Pron, & Diamant, 2000;

McCullough, Wertz, & Rosenbek, 2001; Ramsey, Smithard, & Kalra, 2003; Singh & Hamdy, 2006; Smithard et al., 1998; Splaingard, Hutchins, Sulton, & Chaudhuri, 1988).

Clinical assessment has been shown to miss up to 40% of those patients who aspirate: the so called silent aspirators. Silent aspiration is defined as aspiration without cough or other signs of distress. It appears to be a phenomenon that occurs in healthy adults during sleep and in many disease states (Huxley, Viroslav, Gray, & Pierce, 1978). Reasons for silent aspiration might include central or local weakness or incoordination of the pharyngeal musculature, reduced laryngopharyngeal sensation and impaired ability to produce a reflexive cough (Hammond & Goldstein, 2006; Horner & Massey, 1988; Ramsey, Smithard, & Kalra, 2005).

Several studies have examinded clinical factors that may correlate with aspiration on VFSS or FEES with variable success. An abnormal volitional cough and an absent gag reflex have been suggested as predictive of aspiration by several authors (Daniels et al., 1998; Gordon, Hewer, & Wade, 1987; Smithard et al., 1998). Others found no significant relation between these two parameters and aspiration (Ramsey, Smithard, Donaldson, & Kalra, 2005). Daniels et al (1998) investigated a collection of 6 features (dysphonia, dysarthria, abnormal volitional cough, cough after swallow and voice change after swallow) which correlated with aspiration. Dysphonia was also identified as strongly linked to aspiration by Horner et al (1988). In a review by Ramsey et al. (2003) a wet voice, weak voluntary cough, cough on swallowing, prolonged swallow, or a combination of these are mentioned as the most predictive indices of aspiration.

McCullough et al. (2001) performed a clinical swallowing assessment containing four parts: history, oral motor/speech praxis, voice and trial swallow, to identify predictors of aspiration on VFSS. Two items were identified as reliable, sensitive and specific. Firstly, cough after swallowing, which was reported as being associated with aspiration by Daniels et al (1998). Secondly, the overall judgment by the examiner about the probability of aspiration (Daniels et al., 1998; McCullough, Wertz, & Rosenbek, 2001). None of the history items or the oral motor/speech signs met the criteria for sensitivity and specificity (McCullough, Wertz, & Rosenbek, 2001). According to Martino et al. (2000), only two screening tests were identified as accurate: failure on the 50ml water test and impaired pharyngeal sensation.

Despite the great number of studies looking at clinical factors correlating with aspiration it is very difficult to compare data. There are unavoidable differences in the characteristics of the stroke populations, like age, comorbidity and type of stroke. The patient's overall condition, the severity of the stroke and probable spontaneous recovery varies greatly. Concerning spontaneous recovery, findings may change depending on the time the patient was assessed. Most studies only assessed swallowing physiology over a short period of time. Additionally, almost every study used different criteria and protocols. Most of them tried to compare their findings with VFSS. To rely strongly on VFSS as the current gold standard causes other problems. VFSS is an examination and not a natural feeding situation. It provides only a snapshot of swallowing function and the protocols used to document the findings of VFSS differ. Also the interpretations of the results depend on the assessor's experience and training.

As previously stated, clinical assessments have low sensitivity and specifity for detecting aspiration. But this is not the only purpose of clinical assessments. It is important to define the overall strengths and limits of the patient by assessing the oromotor function and the oral intake. These examinations do not require special equipment and are easy to perform even at patients' bedside. The observation of oral intake is actually looking at what we really want to assess: swallowing of boluses. Daniels et al (1998) suggested that detailed and precise clinical assessments are important for early detection of patients who need an instrumental examination and to guarantee proper management (Daniels et al., 1998). These findings might provide important information about the therapeutic needs for safe and efficient nutrition (McCullough et al., 2005; McCullough, Wertz, & Rosenbek, 2001) There is still a need for a reliable clinical assessment tool to reduce dysphagic complications and the overall healthcare costs (Ramsey, Smithard, & Kalra, 2003).

1.5.1 Water Swallow Test

Many researchers have assessed swallowing difficulties by drinking water (Ramsey, Smithard, & Kalra, 2003). To give the patient small amounts of water to swallow and document qualitative features is widely used in clinical practice (McCullough, Wertz, Rosenbek, & Dinneen, 1999; Tohara, Saitoh, Mays, Kuhlemeier, & Palmer, 2003).

Gordon et al. (1987) asked acute stroke patients to drink 50 ml of water continuously while evaluating for signs of dysphagia. The test was abnormal when the patient was not able to finish the whole amount of water or if choking occurred during two trials. Abnormal tests were associated with higher incidence of chest infection but these findings were not statistically significant (Gordon, Hewer, & Wade, 1987). Kidd et al (1993) performed a similar study to assess the occurrence of aspiration in acute stroke. Oromotor function was assessed and a

50ml water swallow test was performed and compared with the occurrence of aspiration on VFSS. A significant association between failure on the 50ml water test and aspiration on VFSS was found (Kidd, Lawson, Nesbitt, & Macmahon, 1993).

McCullough et al. (1999) used a 5ml water test as a part of a whole battery of bedside assessments to detect aspiration in stroke patients. Only two signs were identified to successfully detect aspiration: spontaneous cough during swallowing and the overall estimate of the probability of aspiration (McCullough, Wertz, & Rosenbek, 2001). Tohara et al (2003), Lim et al. (2001) and Mari et al.(1997) found similar results in performing the 85ml water swallowing test (Lim et al., 2001; Mari et al., 1997; Tohara, Saitoh, Mays, Kuhlemeier, & Palmer, 2003). Most of these water swallow tests use qualitative measurements only, like documentation of coughing or choking during the swallow or wet-dysphonia after swallowing. This provides important information, but the evaluation is subjective and it is not possible to detect the 40% who are silently aspirating.

Several studies tried to objectify the ingestion of water. Nilsson et al (1996) performed the quantitative ROSS test, where patients were instructed to drink 200ml of water with a straw in single swallows and in repetitive swallows.

One hundred stroke patients were asked within 24h of stroke onset about swallowing difficulties. They were considered to have Dysphagia if they reported; (1) they could not eat or drink normally, (2) food got stuck in their mouth or throat, (3) they coughed during or after swallowing. The findings suggest that the sensitivity in detecting dysphagia was increased in repetitive swallows. The differences shown in repetitive swallowing, compared to the reference values were more pronounced and constant (Nilsson, Ekberg, Olsson, Kjellin, & Hindfelt, 1996).

Hughes and Wiles, 1996, have validated a ‘water swallow test’ which included ingestion of 150 ml of water and documentation of both qualitative and quantitative measures. Qualitative aspects include slowness, coughing, voice quality post swallow or breathlessness. Three quantitative indices are derived: volume per swallow, time per swallow and swallows over time. According to the authors this assessment provides valuable information for documenting swallowing efficiency and measures the level of disability. The results showed significantly reduced swallowing capacity in patients with motor neuron disease compared to the normal subjects. In addition to the qualitative description of swallowing, the quantitative measures are objective and therefore more meaningful (Hughes & Wiles, 1996).

Hinds & Wiles (1998) investigated 115 patients with acute stroke using a questionnaire related to their ability to swallow, structured examination and the timed water swallowing test. The structured examinations were used to assess the activities of daily living (Barthel score), motor power (Motility index), and cognitive impairment (Short Orientation Concentration Test). The aim of the study was to validate the timed water swallow test and estimate the clinical features which are important to assess swallowing in stroke. Their outcome variables included referral to and intervention by a speech and language therapist (SLT), dietary modification, respiratory complication, and death. The findings did not show an increased incidence of death or chest infections with abnormal water swallow test. But these subjects were at an increased risk to need dietary modification or intervention by a SLT (Hinds & Wiles, 1998).

Nathadwarawala et al (1992) tested the validity of the timed water swallow test comparing the patients' complaint of abnormal swallowing with the swallowing speed (ml/s) in a group of neurological patients. They used a questionnaire to evaluate symptoms of abnormal swallowing. Swallowing speed was defined as abnormal if less than 10ml per second. The findings suggest a strong correlation between noticed problems and swallowing speed. Decreased swallowing speed as a symptom might provide additional information about the underlying pathophysiology for swallowing difficulties. It is a reliable and valid supplement to other clinical examinations (Nathadwarawala, Nicklin, & Wiles, 1992).

The measurement of swallowing efficiency using the timed water swallow test could be a valuable adjunct to the usual assessment techniques. Patients need to be conscious and should be able to sit upright. The water swallow test is easy to perform and does not require special equipment.

1.5.2 Laryngopharyngeal sensation

Several studies identified impaired laryngopharyngeal sensation as a predictor of aspiration and it is documented in the literature as a possible reason for silent aspiration. Kidd et al. (1993) showed a strong association between aspiration and pharyngeal sensation. Pharyngeal sensation was tested by applying the tip of an orange stick on each side of the pharyngeal wall. The subjects were asked about the presence and the difference between the stimuli and the movement of the pharyngeal constrictors was documented (Kidd, Lawson, Nesbitt, & Macmahon, 1993).

Aviv et al. (1997) used two methods to determine laryngopharyngeal sensory discrimination thresholds using air pulse stimulation of pyriform mucosa and aryepiglottic folds. The first method was psychophysical testing. An air pulse with a variable pressure rate was used to define subjects' sensory threshold. The subjects were asked to raise their hand once they felt the air pulse. In the second method, laryngopharyngeal sensory threshold was reached when the laryngeal closure reflex was elicited. The findings suggested a strong association between bilateral laryngopharyngeal sensory deficits and the development of aspiration pneumonia (Aviv et al., 1997).

According to Setzen et al. (2000), an absent laryngeal adductor reflex, which is defined as transient vocal fold closure, determined by observation of the laryngopharynx, puts patients with dysphagia at risk for penetration and aspiration. There appears to be a strong association between hypopharyngeal sensory deficits and hypopharyngeal motor function deficits (Setzen, Cohen, Mattucci, Perlman, & Ditkoff, 2001).

1.5.3 Cough and Aspiration

Hypopharyngeal motor function is important not only for swallowing but also for coughing (Hammond & Goldstein, 2006). The cough is a protective reflex to clear the respiratory tract (Chung, 1996, , 2002; Pantaleo, 2002). The cough reflex is elicited in response to inhaled or aspirated substances in the upper airway (Jordan, 1996; Karlsson, 1996).

Afferent fibres mediated by the vagus nerve and terminating in the airways feed into the NTS of the brain stem (Bolser & Davenport, 2002; Mazzone, 2004, , 2005; Sant'Ambrogio & Sant'Ambrogio, 1996). In contrast to the reflexive cough (RC), the voluntary cough (VC) is cortically mediated and, thus, can be produced on command (H. A. Hutchings, Eccles, R., Smith, A.P., Jawad, M.S.M., 1993; Lee, Cotterill-Jones, & Eccles, 2002). As people with swallowing difficulties are at risk of aspirating and developing pneumonia, cough as a mechanism of airway protection, is essential (Addington, Stephens, & Gilliland, 1999; Nishino, Tagaito, & Isono, 1996; Sekizawa, Ujiie, Itabashi, Sasaki, & Takishima, 1990; Smith & Wiles, 1998).

1.5.4 Inhalation Cough Challenge

Cough can be evoked in humans by inhalation of different substances (Widdicombe, 1996). The cough reflex has been explored during the last 40 years by using inhalation cough challenge (Fuller, 2002; Morice, 1996). Originally, cough provocation testing was developed to investigate new antitussive agents. Inhalation cough challenge means that tussive stimulants are vaporised using a nebuliser and the provoked coughs are documented. Two different kinds of nebuliser are used for inhalation cough challenge: the ultrasonic and the jet nebuliser. The character of the produced aerosol is influenced by the number of particles per litre, which distinguishes the two different types of nebuliser (Morice, 1996). Additionally Barros et al. (1990) reported the importance of the inspiratory flow rate as a variable in the citric acid cough challenge by documenting significant differences in cough response between two extreme flow rates. In previous reports using such challenges the inspiration flow rate has not been standardized (Barros, Zammattio, & Rees, 1990).

Mainly two methods are used for cough challenge: the single dose and the dose response inhalation. The single dose inhalation is primarily used to screen a large population for reproducible cough using a single dose of the tussive agent. The dose-response method on the other hand involves the application of successively increased concentrations. According to the length of inhalation the method can be divided in “single breath” or “fixed/time inhalation, challenge” (Morice, 1996; Morice, Kastelik, & Thompson, 2001).

Many different tussive agents are used in the development and testing of the inhalation cough challenge, including sulphur dioxide and cigarette smoke. However, three groups of substances are most frequently used: capsaicin, organic acids and low chloride solutions. The most frequently used acid stimulants, especially in pharmacological experiments, are citric and tartaric acid (Morice, Kastelik, & Thompson, 2001).

It has been reported that citric acid stimulates nerve fibres within the larynx and the upper airways. The most commonly used non-acid tussive agent is capsaicin, a stinging agent of hot pepper.

Very few studies looked at the cough reflex after stroke. Kobayashi et al examined the cough reflex using nebulised citric acid and the swallowing reflex by injecting 1ml of water into the pharynx through a nasal catheter in stroke patients compared to a control group. The findings suggest a depression of both reflexes within the first two weeks post onset of stroke (Kobayashi, Hoshino, Okayama, & Sekizawa, 1994)

Addington et al. (1999) utilised nebulised tartaric acid to evaluate chemosensory cough reflex in stroke. A 20% solution of tartaric acid dissolved in 2ml sterile saline was vaporised using a nebuliser. The test was finished when there was a cough response or the subject did not respond to the stimulation .after a maximum of three trials. Additionally a clinical swallowing evaluation, a test for cognition, a voice test pre- and post swallow and a cranial nerve examination was performed by the SLT. The swallowing examination consisted of "2part water test", an observation of oral intake and the evaluation of voluntary cough. The water swallow test measured the ability to keep two different amounts of water in the mouth. The findings showed that an absent response to the cough challenge was a better predictor of lung infection than an abnormal voluntary cough. The authors suggest that the neurological examination of the laryngeal cough reflex and airway protections is more important in regard to pneumonia risk than the physiological examination of dysphagia (Addington, Stephens, & Gilliland, 1999).

Subsequent researchers have utilised other chemicals, such as citric acid, and preliminary normative data are available. Niimi et al. (2003) used capsaicin to measured cough sensitivity and mucociliary function in seven patients with recurrent pneumonia compared to a control group. The patients had no underlying condition. Cough threshold was reached when five or more coughs were evoked by inhaling ten doubling concentration of capsaicin solution. Additional, mucociliary clearance was evaluated by measuring nasal ciliary beat frequency and nasal clearance time. The findings suggest that decreased cough reflex might be involved in the development of recurrent pneumonia (Niimi et al., 2003).

Nakajoh et al. (2000) tried to assess the relation between cough and swallowing reflexes and incidence of pneumonia in stroke patients with oral or tube feeding. The cough reflex was evaluated using nebulised citric acid. They injected distilled water into the pharynx using a nasal catheter to assess the swallowing reflex measuring the latency of response. The findings indicate a significant correlation between decreased swallowing and cough reflex and pneumonia. Additionally, the incidence of pneumonia in patients with tube feeding was 4.1 times lower than in the ones with oral feeding (Nakajoh et al., 2000).

As previously stated, one main problem of clinical assessments is silent aspiration. To define an absent cough reflex as a symptom of silent aspiration might be of clinical value.

1.6 Research Objective

The aim of this study was to detect clinical changes in parameters of swallowing function in patients post acute cortical stroke. As effective clinical identification of patients with dysphagia is the first step in appropriate management, and diagnostic techniques such as videofluoroscopy may not be possible due to patient clinical status or limited availability of videofluoroscopy, it is critical to develop clinical assessment procedures that are sensitive and specific in the detection of dysphagic features. More objective techniques as the timed water swallow test and a cough reflex test might improve clinical assessments.

It is hypothesised that:

a) Objective measures of swallowing parameters (water swallowing test and inhalation cough challenge) will detect changes in swallowing impairment with greater sensitivity than subjective examinations (observation of oral intake and cranial nerve assessment).
b) The average swallowing capacity and the average volume per swallow, as measured by a timed water swallow test (Hughes and Wiles, 1996), will increase progressively across the testing period.
c) Chemoreception within the aerodigestive tract, as measured by an inhalation cough challenge, will increase progressively across the testing period.

Published studies which have assessed the natural history of swallowing using bedside assessments have only observed swallowing for a short period of time; longitudinally well designed studies are needed for more conclusive evidence of screening benefit.

2 Chapter

Methodology

2.1 Participants

Research participants included 26 consecutive consenting adults admitted to the regional Public Hospital with a diagnosis of acute cortical stroke from July 2007-October 2007. Inclusion criteria included acute cortical stroke within 72 hours of admission to the Acute Stroke Unit (ASU), approval from the patient's responsible physician for study participation and an informed consent signed by the patient or a proxy. Exclusion criteria were uncertain clinical diagnosis of cortical stroke or co/existing degenerative neurological disease such as Parkinson's or motor neuron disease.

2.2 Procedures

New admissions to the ASU were identified by the admitting physician or house physician and the stroke unit clinical nurse specialist. Approval to approach the patient was obtained from the physician or clinical nurse specialist who was directly involved in the patient's care. Patients and/or appropriate relatives were then approached directly by the researcher in the ASU. They were provided with an information sheet and verbal information regarding the nature, scope, and potential risks associated with the project.

Upon receipt of informed consent, a standardised clinical swallowing assessment was performed within 72 hours of admission. This examination consisted of a cranial nerve assessment, an observation of oral intake, a timed water swallowing test and a citric cough challenge.

The first component of the assessment was a standard sensorimotor behavioural examination of cranial nerves 5, 7, 9, 10 and 12 with observation and documentation of strength, range of motion, symmetry of movement and sensation. Observable features of cranial nerve impairment were documented as: significant and strongly lateralising, mild and lateralising, significant and nonlateralising, mild and nonlateralising or normal (see Appendices A, Table 1: Cranial nerve examination).

The second component included observation of oral ingestion. The participants were given four different textures: thin liquid (15 ml water), thick liquid (15 ml kiwi nectar), puree (15 ml plain yoghurt), and dry solid (bite of biscuit). Three trials of each texture were evaluated. Observable features of swallowing pathophysiology were documented as: consistently present, inconsistently present or absent (see Appendices A, Table 2: Observation of oral intake). The features evaluated within the oral phase were anterior spillage, post swallow oral residual, poor bolus cohesion, and prolonged oral phase duration.

In the oral transit phase, pre-swallow coughing and respiratory resumes pre swallowing were evaluated. The features of multiple swallows, change in vocal resonance, and pharyngeal expectoration were chosen to assess pharyngeal swallowing physiology. In the cricoesophageal phase, multiple swallows, change in vocal resonance and struggling behaviour were evaluated. The features for the laryngeal phase were immediate cough, latent cough, weak cough, and wet dysphonia after swallowing.

If a particular food/fluid substance resulted in repeated severe clinical signs of aspiration such as coughing, wet dysphonia, and shortness of breath, evaluation of that substance was discontinued and the test was limited to tolerated textures or was discontinued as appropriate.

Thirdly, swallowing efficiency was tested using the timed water swallowing test described by Hughes and Wiles (1996). Participants were asked to drink 150ml of water from a plastic beaker “as quickly as was comfortably possible”. The number of swallows was counted by observing the movement of the thyroid cartilage. A stop watch was started when the water first came in contact with the bottom lip, and was stopped when the larynx came to rest following the final swallow. If there were clinical signs of aspiration such as coughing, wet dysphonia or shortness of breath, the test was titrated to a smaller quantity or was discontinued as appropriate (see Appendices A, Table 3: Timed water swallow Test).

The laryngeal cough reflex was evaluated by using an inhalation challenge. This method was similar to a protocol described by Morice, Kastelik, and Thompson (2001). Citric acid was diluted in 0.9% sodium chloride to gain concentrations of 1M and 2M and 2ml of each concentration was put in the vial for nebulisation. These concentrations were chosen according to a preliminary study by Leow, et al. (manuscript in preparation, 2007) and represent the concentration where all healthy participants reached the natural natural cough threshold and the threshold for suppressing the cough.

Participants were told that they would breathe in moist air with citric acid that could make them cough. They were asked to cough “when they felt the need to cough”. A nose clip was placed to force oral inspiration and a DeVilbiss nebuliser with a constant flow rate of 8L/min regulated the flow of nebulised citric acid. Participants were instructed to fully exhale to functional residual capacity, and then to place the mouthpiece of the nebuliser into their mouths to form a good seal and fully inhale. Presence or absence of cough within the first 10 seconds was documented. This was repeated 3 additional times with the same concentration at 30 sec intervals.

The cough reflex at a given concentration was identified as present when participants coughed at least twice within the first ten seconds in at least two out of the four inhalations (50%). To assess suppressed cough, participants were asked to "try to suppress the cough as much as they can". The suppressed cough threshold was reached when participants coughed at least twice out of four inhalations (50%) of that dose. In the beginning, a placebo (0.9% Sodium chloride) dose was presented to coach the participant. The entire assessment was repeated at one week, one month and three months after the first evaluation.

2.3 Data Analyses

For this exploratory study, descriptive statistics were used. SPSS (Statistical Package for the Social Sciences) Version 15.0 for Windows was employed for data exploration. Observational data from the cranial nerve assessment and observation of oral intake were coded such that the greater severity and greater number of pathophysiologic features represented a higher score. They were analysed using the Friedman's Test for nonparametric repeated measures comparisons. Data from the water swallow test were inherently interval data; therefore, RM ANOVA was conducted to evaluate for change in these variables across testing sessions.

Chi^2 Analyses were used to evaluate changes in cough reflex testing, which were characterised as binary data.

3 Chapter

Results

3.1 Patients

The study recruited 26 consenting patients (10 females, 16 males), mean age 78 years (range 44-93years). The entire first assessment was performed with a total of 24 participants. One female dropped out of the study before the first assessment was performed due to a worsening of her general condition and inability to participate. One participant, who was initially diagnosed with a cortical stroke, was later identified to have had a brain stem stroke and was excluded from the study. The remaining 24 patients suffered from cerebral hemispheric stroke diagnosed clinically and frequently confirmed by CT.

Seven patients were classified as normal according to the overall judgement of the examiner and their scores in the first assessment and were excluded from the statistical analyses. A complete dataset across all four sessions was obtained for only 11 subjects. Some entire assessments or parts of the subtests were not performed in the other 13 participants due to patients' medical or mental status or personal reasons. The incomplete datasets were not used.

3.2 Inter-rater-reliability

To assess inter-rater reliability of examination procedures, an additional observer documented the patients' performance during 14 randomised assessments. There was high inter-rater-reliability for all subtests, range .805 for the assessment of the cranial nerve exam: close eyes – 1.000 for the assessment of several subtests (see Appendices B).

3.3 Cranial Nerve Exam

Observable features of cranial nerve impairment were analysed using a scale from 0 to 5, the higher the score the bigger the impairment. The tasks of the cranial nerves were added up to a total score for each nerve divided into motor or sensory function.

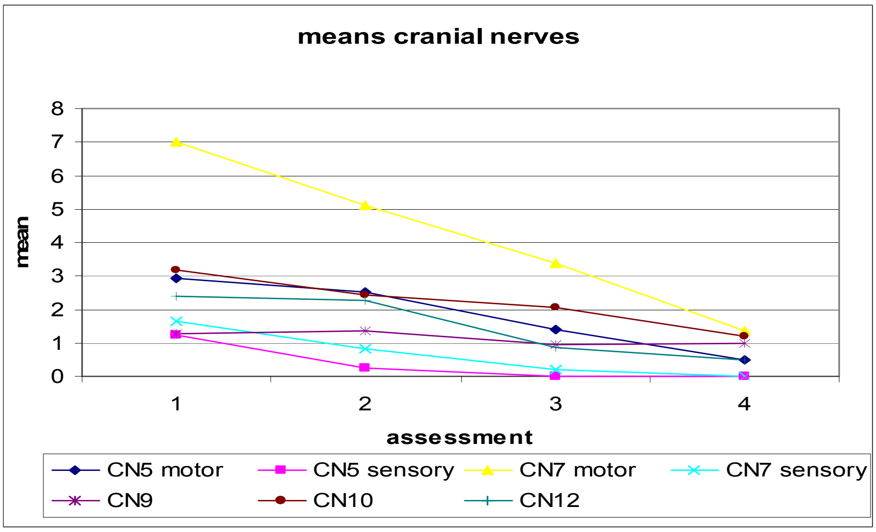

Figure 1

The means (see Figure 1) show a clear improvement over the four testing periods. CN7 motor with a mean score of 7 is the most impaired of the tested cranial nerves. By the fourth assessment, the mean score for CN7 is nearly 1.

Thirteen complete data sets were analysed. Data missing points on the other 11 participants prevented their inclusion in repeated measure comparison. Friedman's Test (non-parametric repeated measures comparisons) showed significant main effects for all five tested cranial nerves across the four testing periods (see Table 1).

Table 1: Friedmans Test: Cranial nerve examination

Variable	N (full dataset)	df	χ^2_F	p
Cranial nerve 5 motor	13	3	20.381	.000*
Cranial nerve 5 sensory	13	3	24.641	.000*
Cranial nerve 7 motor	13	3	11.857	.008*
Cranial nerve 7 sensory	13	3	11.857	.008*
Cranial nerve 9	13	3	12.600	.006*
Cranial nerve 10	13	3	13.441	.004*
Cranial nerve 12	13	3	15.464	.001*

* p significant at < .05 level

Subsequently the Wilcoxons matched pairs analyses identified significant differences across all assessments of CN5 except the first to the second, and the second to the third (See table 2). The first to the fourth and the second to the fourth paired analyses differed most substantively (ass 1 – ass 4, T = .002; ass 2 – ass 4, T = .007). There were significant differences between all assessments in CN5 sensory (see Table 3).

Table 2 Wilcoxons matched-pairs signed-ranks test of Cranial nerve examination CN5 motor

Variable	N	T
Cranial nerve 5 motor		
ass 1 – ass 2	16	.357
ass 1 – ass 3	15	.013*
ass 1 – ass 4	14	.002*
ass 2 – ass 3	14	.061
ass 2 – ass 4	13	.007*
ass 3 – ass 4	14	.033*

* p significant at < .05 level

Table 3 Wilcoxons matched-pairs signed-ranks test of Cranial nerve examination CN 7 sensory

Variable	N	T
Cranial nerve 5 sensory		
ass 1 – ass 2	16	.029*
ass 1 – ass 3	15	.003*
ass 1 – ass 4	14	.001*
ass 2 – ass 3	14	.033*
ass 2 – ass 4	13	.005*
ass 3 – ass 4	14	.007*

* p significant at < .05 level

In both CN7 motor and CN7 sensory there were significant differences between the first and the third assessment and the first and the fourth (CN7 motor /sensory: ass 1 – ass 3, T = .024; ass 1 – ass 4, T = .016).The paired analyses for the CN9 differed significantly between the second and the third assessment (ass 2 – ass 3, T = .014) as well as between the second and the fourth assessment (ass 2 – ass 4, T = .025). For CN 10, the first and the fourth (ass 1 – ass 4, T = .044) and the second and the fourth assessment (ass 2 – ass 4, T = .007) differed significantly.

CN12 showed significant differences between all assessments except the first and the second and third and the fourth (see Table 4).

Table 4 Wilcoxons matched-pairs signed-ranks test of Cranial nerve examination CN7 to CN12

Variable	N	T
Cranial nerve 7 motor		
ass 1 – ass 2	16	.078
ass 1 – ass 3	15	.024*
ass 1 – ass 4	14	.016*
ass 2 – ass 3	14	.276
ass 2 – ass 4	13	.157
ass 3 – ass 4	14	.317
Cranial nerve 7 sensory		
ass 1 – ass 2	16	.078
ass 1 – ass 3	15	.024*
ass 1 – ass 4	14	.016*
ass 2 – ass 3	14	.276
ass 2 – ass 4	13	.157
ass 3 – ass 4	14	.317

* p significant at < .05 level

Variable	N	T
Cranial nerve 9		
ass 1 – ass 2	16	.083
ass 1 – ass 3	15	.083
ass 1 – ass 4	14	.157
ass 2 – ass 3	14	.014*
ass 2 – ass 4	13	.025*
ass 3 – ass 4	14	.317
Cranial nerve 10		
ass 1 – ass 2	16	.058
ass 1 – ass 3	15	.121
ass 1 – ass 4	14	.004*
ass 2 – ass 3	14	.369
ass 2 – ass 4	13	.007*
ass 3 – ass 4	14	.074

Variable	N	T
Cranial nerve 12		
ass 1 – ass 2	16	.788
ass 1 – ass 3	15	.009*
ass 1 – ass 4	14	.005*
ass 2 – ass 3	14	.025*
ass 2 – ass 4	13	.011*
ass 3 – ass 4	14	.102

* p significant at .05 level

3.4 Observation of Oral Intake

The observation of oral intake (thin liquid, thick liquid and puree) was obtained for 13 patients of all four assessments. Dry solid was only given to 11, due to refusal of the patient or technical problems, like no teeth. The means of the scores for oral intake show a slight worsening between the first and the second assessment, but a clear improvement for all textures between the first and the fourth assessment (see Figure 2).

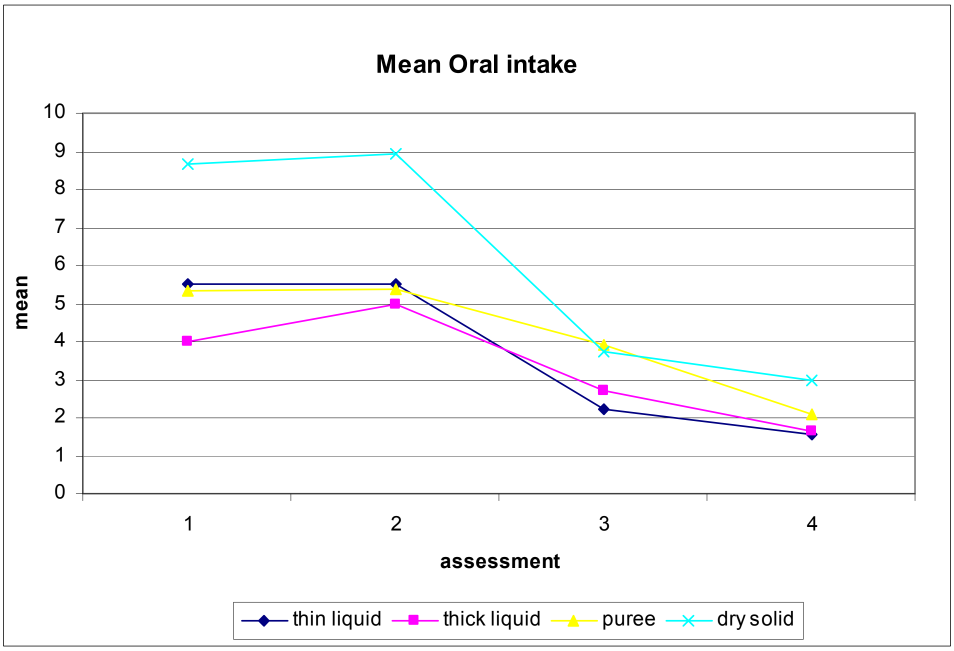

Figure 2

Friedmans' Test identified significant main effects for two textures, thick liquid (χ^2_F [13]= 8.948, p= .030) and puree (χ^2_F [13]= 13.634, p= .003), across the four assessments (see Table 5).

Table 5: Friedman Test for Observation of oral intake

Variable	N	df	χ^2_F	p
Thin liquid	13	3	7.358	.061
Thick liquid	13	3	8.948	.030*
Puree	13	3	13.634	.003*
Dry solid	11	3	4.981	.173

* p significant at .05 level

Consequently Wilcoxons matched pairs analyses were conducted. The second and the fourth assessment of the intake of thick liquid differed significantly (ass 2 – ass 4, T = .018). The intake of puree showed a significant difference between assessment two and four, and assessment three and four (ass 2 – ass 4, T = .016; ass 3 – ass 4, T = .002) (see Table 6).

Table 6: Wilcoxon's matched-pairs signed-ranks test of Observation of oral intake

Variable	N	T
Thick liquid		
ass 1 – ass 2	16	.614
ass 1 – ass 3	15	.892
ass 1 – ass 4	14	.071
ass 2 – ass 3	14	.327
ass 2 – ass 4	13	.018*
ass 3 – ass 4	14	.081
Oral intake		
ass 1 – ass 2	16	.243
ass 1 – ass 3	15	.292
ass 1 – ass 4	14	.134
ass 2 – ass 3	14	.186
ass 2 – ass 4	13	.016*
ass 3 – ass 4	14	.002*

* p significant at .05 level

3.5 Timed Water Swallow Test

The water swallow test was performed in all four assessments with 13 subjects, due to technical problems and consideration for patients' safety.

RM ANOVA identified significant main effects of the variables volume/swallow (F [13]= 3.082, p= .044) and volume/time (F [13]= 3.253 p= .036) (see Table 7).

Table 7: RM ANOVA of Timed Water Swallow Test

Variable	N (full dataset)	df	F	Sig.
volume / swallow	13	3	3.082	.044*
time / swallow	13	3	2.634	.070
volume / time	13	3	3.253	.036*

* p significant at .05 level

Consequently the paired sample t-test showed that assessments one and two of the variable 'volume/swallow' differed significantly (t [12]= -3.538 p= .005). The differences across the trials in the variable 'volume/time' were significant between assessment one and three (t [12]= -2.439 p= .031)and one and four (t [11]= -2.518 p= .029) (see Table 8).

Table 8: Paired sample t-test of Timed Water Swallow Test

Variable	N	df	t	Sig.
volume / swallow				
assessment 1 – assessment 2	12	11	-1.118	.287
assessment 1 – assessment 3	12	11	-3.538	.005*
assessment 1 – assessment 4	11	10	-1.959	.079
assessment 2 – assessment 3	12	11	-1.471	.169
assessment 2 – assessment 4	11	10	.602	.561
assessment 3 – assessment 4	12	11	1.992	.072
volume / time				
assessment 1 – assessment 2	12	11	-1.370	.196
assessment 1 – assessment 3	12	11	-2.439	.031*
assessment 1 – assessment 4	11	10	-2.518	.029*
assessment 2 – assessment 3	12	11	-1.188	.260
assessment 2 – assessment 4	11	10	-1.238	.244
assessment 3 – assessment 4	12	11	-1.098	.296

* p significant at .05 level

3.6 Inhalation Cough Challenge

3.6.1 Reflexive Cough Reflex

The inhalation cough challenge using the lower concentration (1M) was performed in 11 subjects over the four testing periods. Data of the other participants are missing due to medical status, cognitive status, or patients availability. The higher concentration of citric acid (2M) was not used if the natural cough threshold was obviously reached at1M. All tested subjects produced a cough at the lower concentration in the first and second assessment. In the third and the fourth assessments two of the tested subjects did not cough. All tested subjects needed to cough at the higher concentration (2M). According to the Chi^2 Analyses there are no significant changes over the four testing periods.

3.6.2 Suppressed Cough Challenge

The suppressed cough challenge using the lower concentration was performed with the participants who needed to cough at this concentration. None of the tested subjects were able to suppress the cough in the first, third and fourth assessment. After one week, one of the tested subjects suppressed the cough successfully. None of the tested subjects were able to suppress the cough at the higher concentration. There were not enough differences for statistical analyses.

4 Chapter

Discussion

4.1 Introduction

The purpose of this investigation was to monitor the natural progression of dysphagic symptoms in stroke over three months using a clinical assessment. Under investigation were four different subtests of a clinical swallowing assessment and their ability to detect changes of dysphagic symptoms over time. Furthermore, it contributes to the ongoing discussion about the use of clinical assessments in practice by identifying which assessment practices are sensitive to changes in patient behaviour. A clinical assessment has many purposes: to screen stroke patients for dysphagic symptoms and aspiration, to decide who is at need of further investigation and to guarantee proper management.

4.2 Findings

At least mild dysphagic symptoms after stroke were documented in 72% of the assessed patients. This figure is quite high compared to other data reported in the literature (Gordon, Hewer, & Wade, 1987; Hinds & Wiles, 1998; Kidd, Lawson, Nesbitt, & Macmahon, 1995; Ramsey, Smithard, & Kalra, 2003; Smithard et al., 1997).

Testing oral motor sensory function and observing patient's eating or drinking are common subjective components of a clinical swallowing assessment. Both subjective clinical examinations documented dysfunction of the neural and muscular components as well as impairment of the ingestion of food and liquid. Additionally the more objective timed water swallow test showed abnormal results for all tested subjects defined as having impaired swallowing. All three subtests documented improvements over the four testing periods. The inhalation cough challenge did not identify an impaired cough reflex after stroke. All subjects needed to cough at the lower concentration in the first assessment; no changes over time were documented.

The performances of some subjects appeared to fluctuate in all subtest except the inhalation cough challenge (i.e., some subjects had more difficulties on a later assessment than on the first one). Reasons for this could be that the assessment was performed at different times of the day over the four testing periods; that the subjects' mental and physical state was different on that day of testing, or it may be that the scale used was not precise enough. Smithard et al (1997) previously stated that that neurological deficit can vary within the first week. Nature of variation could also exist due to the examination. Especially the observation of oral intake differs form a natural feeding situation. There were only three trials per texture, which might not be enough to judge the subjects' performance. The physical position of the subject during the test might also have an important influence on performance. A standardized setting for assessment could improve the comparability of the results of the different testing periods. This might not be feasible due to patients' availability and overall physical and mental state.

This study confirms that the functions of Cranial nerve 5, 7, 9, 10, and 12 are often affected after stroke. It is not surprising that dysfunction of the neural and muscular components involved in swallowing are associated with dysphagia. Several studies have examined the correlation between variables of the oral motor sensory function and dysphagia or aspiration found on VFSS. The only variables mentioned as predictive for dysphagia or aspiration were abnormal gag reflex, voice quality and weak volitional cough (Horner & Massey, 1988; Mann & Hankey, 2001; McCullough, Wertz, Rosenbek, & Dinneen, 1999; Nishiwaki et al., 2005). But these studies did not use a wide range of tasks testing muscles and underlying function of the corresponding cranial nerve. To combine several items testing the cranial nerve enables assumptions regarding the impairment not only of the oral, but also the pharyngeal and laryngeal swallow physiology.

Several features of swallowing parameters identified impaired oral intake. Two textures showed significant changes over time: thick liquid and puree. The features documenting pharyngeal parameters in particular demonstrated significant changes between the four testing periods in swallowing thick liquid. You would expect to see the same results with thin liquid for variables like “multiple swallow”, “pharyngeal expectoration” or “change in vocal resonance”. A possible reason might be that the applied thick liquid (Kiwi Nectar) provided more gustatory input than thin liquid (water). The ingestion of puree on the other hand showed significant changes of the variables for oral parameters which is most likely traceable to the variable “post swallow oral residual”. This texture does not provide as much sensory input as dry solid. A firm texture has to be masticated and patients with mild sensory deficits in the oral cavity or a facial droop might be able to feel the residuals of dry solid and clear it. This is not true for puree. Additionally, it is easier for the examiner to detect residuals of puree in the oral cavity than for liquid.

Studies looking at the correlation between different variables of swallowing test boluses identified “spontaneous cough while swallowing” as the only one predictive for aspiration on VFSS (McCullough, Wertz, & Rosenbek, 2001). Compared to this study, often only liquid textures were used and the variables were documented as “present or absent” in one representative trial.

All tested subjects defined as having impaired swallowing had an abnormal water swallowing test. The variables volume/swallow and volume/time showed significant changes over the four testing periods. This supports the findings of Hinds et al. (1998) which identified swallowing capacity or "volume/swallow" as the most sensitive predictor for further need of SLT intervention (Hinds & Wiles, 1998).

Many subjects were not able to drink the whole amount of water and their performances fluctuated over the four testing periods. Additionally, the influence of the SLT might play an important role. Subjects seen by a SLT learned different strategies to improve swallowing safety, like taking small sips, holding the bolus for some time in the mouth before swallowing or clearing the throat after every swallow. These compensatory strategies change the subjects drinking habits, which influences the result of the timed water swallow test.

In some subjects who showed no clinical symptoms at the single water swallow trials, qualitative features like cough or throat clearing after swallowing were documented in these repetitive swallows. This would go with the findings of Nilsson et al (1996) suggesting that the sensitivity in detecting dysphagia was increased in repetitive swallows compared to single swallows.

Decreased swallowing capacity itself is not an indicator for dysphagia, because too many factors may have an influence. But it is definitely a valuable adjunct to the usual performed swallowing assessment. A mild impaired swallowing system might manage single swallow trials without any clinical symptoms, which may occur when we stress the system.

All tested subjects reached the natural cough threshold at a concentration of 1M in the first assessment. The fact that everyone needed to cough at the lower concentration does not necessarily mean that they did not have sensory deficits. The concentration of citric acid of 1M is quite high. This concentration was chosen due to a preliminary study by Leow, et al. (manuscript in preparation, 2007). The findings showed that almost every tested healthy participant needed to cough at this concentration. Choosing such a high concentration, the participants who did not cough are considered to have an impaired cough reflex. None of the participants who coughed at the lower concentration were able to suppress the cough permanently at the same concentration which might imply that the concentration was too high.

The cough threshold of two patients fluctuated over the four testing periods. Previous studies demonstrated a wide range of inter- and intraindividual reaction to citric acid. However, the cough threshold was reproducible with control of time of the day the test is performed, the inspiratory flow rate, and the type of inhalation (Pounsford & Saunders, 1985). In this study, the time of the day of testing varied a lot between the four trials. Furthermore, there was no control over the inspiratory flow rate. Due to patients' present mental or physical status, performance on the inhalation could have been quite different as well.

Cough can be controlled voluntarily, which means that it can be initiated deliberately and can also be suppressed for some times. The results of Hutchings et al (1993) demonstrate that cough as a result of upper respiratory tract infection can be suppressed (H. A. Hutchings, Eccles, Smith, & Jawad, 1993). These findings demonstrate the involvement of the cortex in coughing. There is experimental evidence that the cough required consciousness (Lee, Cotterill-Jones, & Eccles, 2002). Cough response is decreased during sleep and the cough threshold to the inhalation of citric acid is increased in sleep (Wang, Nakagawa, Sekizawa, Kamanaka, & Sasaki, 1998).

The mechanism of the suppression of cough is not fully clear. The cough threshold might be increased during the suppression. The findings of Hutchings et al (1993) suggest that the sensory input adds up during the suppression which increases the frequency of coughing afterwards (Hutchings, Eccles, Smith, & Jawad, 1993). This implies that if the sensory input of the stimulus is very high, the cortex is not able to suppress the cough. None of the tested subjects were able to suppress the cough permanently over the four testing periods, which indicates that concentrations were too high. It would be valuable to perform the inhalation cough challenge using different concentrations in stroke patients compared that to a control group.

A next step would be to compare the findings of this clinical assessment with an instrumental examination.

4.3 Limitations

Only consenting patients were included in the study. This biased group might not represent the stroke population. Most of the participants who signed the consent form had a mild stroke. The severely affected ones felt too sick or weak to join the study, or were not able to make such a decision on their own. In that case the relatives were contacted. Often it was not possible to get hold of them and have the consent form signed within 72 hours of admission to perform the first assessment in time. On the other hand the patients, who were very mildly affected or had no difficulties at all, were not, or only for a very short time, admitted to the acute stroke unit or did not see a benefit of entering the study. Furthermore, this study was not part of the usual health care in the hospital and many of the patients expressed that this would be too much for them. The outcome of the study would most likely be different with a more heterogeneous group of participants.

There was a substantial loss of data over the four testing periods. This occurrence might indicate that the physical and mental health status is quite unstable recently after a stroke. The performance of the first assessment was not possible in some patients within 72hours of admission due to their medical status. Another reason might be that a lot of the participants went to a rehabilitation clinic or even home within the three months. Although the researcher tried to follow and visit the participants wherever they were, the availability was limited due to medical or mental status or patients' personal reasons.

As previously stated this project was something additional to the usual health care and therapies the participants got. It would have been easier for an already involved therapist to perform the assessments. Someone who works in the same institution knows more about the patients' appointments and is more flexible to schedule around them.

In this study, dysphagia was diagnosed by the Speech and Language Therapist interpreting the overall clinical symptoms. In most cases this diagnose was not confirmed by an instrumental examination. As previously stated, clinical assessments are criticised to have low sensitivity and specifity in detecting aspiration. An instrumental confirmation of the clinical findings would be fundamental for further studies.

5 Chapter

Conclusion

This study provides further information about the clinical changes in parameters of swallowing function in patients with acute cortical stroke. The results of this study offer an indication of the value of an assortment of different examination techniques. The timed water swallow test provides a valuable and objective adjunct to the subjective observation of oral intake, and allows comparisons over time. The inhalation cough challenge, as an indicator of airway protection is a valuable clinical assessment tool concerning the high percentage of silent aspirators. Further studies are needed to specifically investigate the natural cough threshold in stroke and to compare the findings of this assortment of clinical parameters with an instrumental swallowing assessment as FEES or VFSS. An assortment of different assessment tools may predict dysphagia. These data suggest that a detailed clinical assessment consisting of subjective and objective examinations is important for detecting acute stroke patients who are dysphagic and at risk of aspiration and to guarantee a proper management. A clinical assessment is not supposed to replace an instrumental examination but may help to establish which patients need FEES or VFSS. A proper identification of the patients who are dysphagic and at risk of aspiration may reduce complications and the overall healthcare costs.

Appendices A

Clinical Assessment Form

Table 1: Cranial Nerve Examination:

CN		Tested by:	Observation:					Notes:
			SL	ML	SNL	MNL	N	
5 Trigeminal	Motor	jaw open						
		jaw lateralisation						
		bite						
	Sensory	sensory to face						
		hard palate						
		anterior tongue						
7 Facial	Motor	close eyes						
		wrinkle brow						
		smile						
		kiss, whistle						
		flatten cheeks						
		lateralise lips						
	Sensory	taste to anterior 2/3 tongue						
		sensory to soft palate						
		adjacent pharyngeal wall						
9 Glos-soph	Motor	gag reflex						
	Sensory	gag reflex						
		estimation of onset of swallow						
10 Vagus	Motor	vocal quality						
		volitional cough						
		glottal coup						
	Sensory	reflexive cough						

Table 1: Cranial Nerve Examination:

			SL	ML	SNL	MNL	N	
12 Hypogl	Motor	lingual movement superior						
		lateral						
		protrusion						
		retraction						
	SL = significant + lateralising; ML = mild + lateralising; SNL = significant + no lateralising; MNL mild + no lateralising; N = normal							

Table 2: Observation of oral intake:

	Oral				Transit		Pharyngeal		Crico-esoph		Laryngeal		
	Anterior spillage	Post swallow oral	Poor bolus	Prolonged oral	Resp resumes pre-	Pre-swallow	Multiples swallows	Pharyngeal Change in vocal	Multiple swallows	Struggling	Immediate cough	Latent cough	Wet dysphonia
Thin liquid													
Thick liquid													
Puree													
Dry solid													
C = consistently present; I = inconsistently present; A = absent													
Comments:													

Table 3: Timed water swallow Test:

Water swallow Test (Hughes and Wiles, 1996)					
150ml					
Time	**# Swallows**	**Volume**	**V / S**	**T / S**	**V / T**
Notes					

Table 4: Inhalation cough challenge:

Natural cough	Trials	Mole	Results
1.concentration	○ ○ ○ ○	Placebo	
2.concentration	○ ○ ○ ○	1M	
3.concentration	○ ○ ○ ○	2M	
Suppressed cough			
1.concentration	○ ○ ○ ○	Placebo	
2.concentration	○ ○ ○ ○	1M	
3.concentration	○ ○ ○ ○	2M	
Notes:			

Appendices B

Inter-rater-reliability

Variable	ICC	Variable	ICC
Cranial nerve exam		struggling behaviour	1.000
jaw opening	1.000	immediate cough	.902
jaw lateralisation	1.000	latent cough	.928
bite	.996	wet dysphonia	.983
sensory to face	.960		
sensory to hard palate	1.000	Puree	
sensory to anterior tongue	1.000	anterior spillage	.993
close eyes	.805	post swallow oral residual	1.000
wrinkle brow	.939	poor bolus cohesion	1.000
smile	.969	prolonged oral phase	1.000
kiss, whistle	.994	respiratory resumes pre-swallowing	1.000
flatten cheeks	.893	pre-swallow coughing	1.000
lateralise lips	.997	multiple swallows	.992
taste anterior 2/3 of tongue	.977	pharyngeal expectoration	.989
sensory soft palate	.995	change in vocal resonance	.983
adjacent pharyngeal wall	.995	struggling behaviour	.988
gag	1.000	immediate cough	.966
onset of swallow	1.000	latent cough	1.000

Inter-rater-reliability

Variable	ICC	Variable	ICC
vocal quality	.928	wet dysphonia	1.000
volitional cough	.919		
glottal coup	.917		
reflexive cough	1.000	Dry solid	
superior lingual movement	.988	anterior spillage	.886
lateral lingual movement	.990	post swallow oral residual	1.000
lingual protrusion	.990	poor bolus cohesion	.908
lingual retraction	1.000	prolonged oral phase	1.000
		respiratory resumes pre-swallowing	1.000
Observation of oral intake		pre-swallow coughing	.908
Thin liquid		multiple swallows	1.000
anterior spillage	.987	pharyngeal expectoration	1.000
post swallow oral residual	1.000	change in vocal resonance	1.000
poor bolus cohesion	1.000	struggling behaviour	1.000
prolonged oral phase	1.000	immediate cough	.991
respiratory resumes pre-swallowing	1.000	latent cough	1.000
pre-swallow coughing	1.000	wet dysphonia	1.000
multiple swallows	.994		
pharyngeal expectoration	1.000	*Timed water swallow test*	
change in vocal resonance	1.000	volume / swallow	1.000

Inter-rater-reliability

Variable	**ICC**	**Variable**	**ICC**
struggling behaviour	1.000	time / swallow	1.000
immediate cough	1.000	volume / time	1.000
latent cough	.994		
wet dysphonia	.995	*Cough reflex test*	
		Natural cough 1M	1.000
Thick liquid		Natural cough 2M	1.000
anterior spillage	1.000	Suppressed cough 1M	1.000
post swallow oral residual	1.000	Suppressed cough 2M	1.000
poor bolus cohesion	.995		
prolonged oral phase	.986		
respiratory resumes pre-swallowing	1.000		
pre-swallow coughing	.939		
multiple swallows	.994		
pharyngeal expectoration	.871		
change in vocal resonance	1.000		

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