THE VALIDITY OF A THREE-PART CRITERIA FOR DIFFERENTIATING BETWEEN DELAYED PHARYNGEAL SWALLOW AND PREMATURE SPILLAGE SECONDARY TO POOR ORO-LINGUAL CONTROL ON VIDEOFLUOROSCOPY

A thesis completed in partial fulfilment of the
requirements for the Degree
of Master of Speech and Language Therapy
in the University of Canterbury

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University of Canterbury

2007

Acknowledgements

Thank you to Hamish for being willing to give up so much in order to take such good care of me while I worked and studied, and for the constant love, support and encouragement.

To my family and good friends who have cheered me on to the finish.

To my supervisor Maggie-Lee for sharing her vast and amazing knowledge of dysphagia with me and working hard to teach me how to think at a postgraduate level.

To Maxine Power for so graciously allowing me to use her data.

Dedicated to Fraser, who was very proud of me.

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Abstract

Background & Aims

The accurate differentiation between a delayed pharyngeal swallow (sensory impairment) and premature spillage secondary to poor oro-lingual control (motor impairment) is essential to effective dysphagia management. However both physiologic abnormalities result in an identical radiographic sign, that of pre-swallow pooling of the bolus in the pharynx. The dysphagia literature does not provide satisfactory guidelines for making this distinction on videofluoroscopy. The purpose of this study was to assess the validity of a three-part rating scale for differentiating between these two impairments.

Methods

Videofluoroscopy was used to evaluate the swallowing of 29 participants presenting with dysphagia following stroke. Sensory thresholds for these participants were established by electrical stimulation of the anterior faucial pillars. The videofluoroscopic swallowing studies were analysed using the three-part rating scale and results from this were compared to sensory thresholds using Pearson's product moment correlation.

Results

There was no significant correlation between the three-part criteria and sensory thresholds. Inter-rater reliability for some measures was poor.

Conclusions

The three-part criteria was not shown to be a valid measure for differentiating between delayed pharyngeal swallow and premature spillage secondary to poor oro-lingual control. Possible explanations for these findings are discussed, including the relevance of faucial pillar sensation to swallowing.

Dysphagia, the impairment of swallowing, commonly occurs as a symptom of serious illness. The etiology of dysphagia varies but may include congenital defects, medical conditions or traumatic damage to the physical or neurological components important to normal swallowing function (Logemann, 1998). The presence of dysphagia can significantly compromise quality of life and health, often resulting in the modification of food and fluid consistencies. In severe cases of dysphagia, the complete cessation of oral intake and consequent reliance on non-oral feeding methods such as nasogastric feeding or percutaneous endoscopic gastrostomy (PEG) may be necessary. Dysphagia can lead to aspiration of fluid and food into the lungs, which in turn may result in aspiration pneumonia (Logemann, 1998). Aspiration pneumonia may increase the length of recovery time, duration of hospitalisation, and the risk of death (Langmore et al., 1998).

Because dysphagia is a prevalent and serious symptom of ill health, it is a major part of a speech-language therapist's workload in the medical setting. Crary and Groher (2003) estimate a speech-language therapist working in a medical setting will have 70-80% of their caseload dedicated to the diagnosis of dysphagia. Ongoing research is crucial to the effective management of dysphagia in a clinical setting as speech-language therapists pursue better outcomes in health and quality of life for their patients.

The Physiology of Normal Swallowing

Swallowing is a complex process reliant on the cohesive inter-working of many physiological components. To assess and describe this process, dysphagia researchers have divided swallowing into a number of stages or phases. Miller (1982) proposed that swallowing consists of three phases: the oral phase which is under voluntary control, the pharyngeal phase which is both involuntary and under voluntary control, and the esophageal stage which is involuntary. Logemann (1983) expanded on this classification of swallowing and described four phases: an oral preparatory phase, an oral phase, a pharyngeal phase and an esophageal phase. The New Zealand Index for the Multidisciplinary Evaluation of Swallowing (NZIMES), a structured rating scale for the analysis of videofluoroscopic swallowing studies developed by Huckabee (manuscript in preparation), also recognises four phases of swallowing but with different terminology and includes an additional phase to describe the activity of the airway during swallowing. The separation of swallowing into individual components is necessary for the detailed study and accurate management of dysphagia, and yet it is important to note that each phase also works interdependently with the other phases (Crary & Groher, 2003; Miller, 1999).

The Oral Preparatory Phase

During the oral preparatory phase of swallowing described by Logemann in 1983, solid boluses that require preparation before they can be swallowed are masticated and moistened with saliva. The salivary glands receive innervation from the facial (VII) and glossopharyngeal (IX) nerves and are stimulated by mastication during the oral preparatory phase (Crary & Groher, 2003). The tongue is active during mastication, working to continually force the bolus between the teeth for further mastication until it is of a suitably processed consistency for swallowing (Crary & Groher, 2003; Logemann, 1998).

Following mastication, the tongue collects the food particles into a cohesive bolus with the aid of the labial muscles. The middle or dorsal portion of the tongue forms a central groove in which a fluid or solid bolus can be maintained (Dodds, Stewart & Logemann, 1990; Miller, 1982; Murray, 1999). Anterior spillage of the bolus from the oral cavity is prevented by the tip of the tongue approximating the alveolar ridge. The approximation of the sides of the tongue with the teeth and the mucosa of the palate seals the oral cavity laterally. The posterior portion of the tongue elevates and the soft palate lowers to seal the oral cavity posteriorly (Dodds, Stewart et. al., 1990; Donner, Bosma & Robertson, 1985; Donner, 1985; Logemann, 1998; McKenzie, 1997; Miller, 1982; Murray, 1999).

Commonly known as a glossopalatal seal or sphincter, the approximation between the soft palate and the back of the tongue is important to prevent pre-swallow pooling of the bolus into the pharynx (Dodds, Stewart et al., 1990; Logemann, 1993; Murray 1999). Aspiration before the swallow may result if the bolus spills into the pharynx prematurely (Logemann, 1993). Although the glossopalatal seal is maintained fairly consistently with liquid boluses during the oral preparatory phase, it is less fixed with solid boluses. Small amounts of food may pass into the pharynx during mastication and prior to onset of the pharyngeal swallow in normal swallowing (Hiiemae & Palmer, 1999; Logemann, 1993; McKenzie, 1997).

The Oral Phase

The initiation of posterior transfer of the bolus by the tongue is the beginning of the oral phase of swallowing (Logemann, 1998). Hiiemae and Palmer (1999) conducted a study into the process of bolus formation and transport in healthy adults using videofluorography. From this study, the authors noted a “squeeze-back” type of movement whereby the bolus is transported through the oral cavity and the anterior faucial pillars. As reported by other authors (e.g. Donner, et al. 1985; Miller, 1982), the tongue contacts the palate in an anterior-to-posterior fashion, squeezing the bolus into the pharynx (Hiiemae & Palmer, 1999).

The propulsive movement of the tongue is the primary contributor to bolus movement and the initiation of swallowing (Crary & Groher, 2003; Miller, 1982). The oral tongue is under voluntary control and actively contributes to the oral phase of swallowing. Movement of the pharyngeal tongue is primarily involuntary and contributes to the pharyngeal swallow (Logemann, 1998). As the bolus is forced posteriorly, the posterior portion of the tongue depresses to provide a channel for the bolus. The soft palate elevates to approximate the posterior pharyngeal wall, thereby opening the glossopalatal seal in conjunction with tongue depression. This soft palate elevation also prevents the bolus from being regurgitated into the nasopharynx (Dodds, Stewart et al., 1990; Donner et al., 1985; Miller, 1982; Murray, 1999). The pharyngeal swallowing response is initiated as the bolus enters the pharynx (Donner et al., 1985). Logemann (1998) states that the pharyngeal swallow should be initiated “by the time the bolus head reaches the point where the mandible crosses the tongue base, as seen radiographically” (p. 29).

Initiation of the Pharyngeal Swallowing Response

Dua, Ren, Barden, Xie and Shaker (1997) evaluated the initiation of the pharyngeal swallow in a study of the coordination between airway protection mechanisms and bolus transit. Previous studies had only investigated the coordination of pharyngeal bolus transit and airway function in the context of isolated swallows. Dua et al. (1997) were interested to discover if the findings from previous studies were confirmed when swallowing was examined over the course of a normal meal. Fifteen healthy participants were evaluated using a combination of videoendoscopy and videofluoroscopy while eating a meal. On 87% of the swallows analysed on videoendoscopy, food was seen in the pharynx during the oral preparatory phase. Saliva from the chewing of coloured gum was seen in the pharynx on 60% of the swallows prior to the onset of swallowing. In 11% of the swallows while chewing gum, saliva extended to the pyriform sinuses prior to the onset of swallowing. Presumably, the use of healthy participants allowed the authors to determine that the presence of food and fluids in the pharynx prior to the onset of swallow was not caused by the delayed onset of pharyngeal swallowing or poor oro-lingual control. The authors propose that the findings from this study demonstrate that food or fluid can extend past areas of the oropharynx such as the anterior faucial pillars and posterior pharyngeal wall without triggering a swallow in the normal individual—areas that are often purported to elicit swallowing when stimulated. The position of the bolus at the onset of swallowing was found to be variable between subjects. The use of normal participants does raise some cautions about the applicability of these findings to disordered populations. In summary, Dua et al. (1997) propose that their findings indicate that sensory input to the entire oropharynx, rather than one distinct area, is necessary for the elicitation of swallowing.

Pommerenke (1928) conducted one of the original studies investigating the most sensate regions for eliciting the swallowing response. Regions of the oropharynx were stimulated by using a blunt glass rod to touch or stroke various areas. Pommerenke (1928) noted considerable variation in individuals reactions to the stimulus but found the anterior faucial pillars to be the region that was most able to elicit swallowing following stimulation. The anterior faucial pillars were then anesthetized with cocaine after which the swallowing response was found to be diminished to at least some degree in all participants. Caution needs to be taken in applying the results of this very early study to the current field of dysphagia research. Nonetheless, this study by Pommerenke (1928) is one that has shaped the course of research into sensation relative to swallowing, particularly the research involving thermal stimulation.

Neural Control of Swallowing

The posterior movement of the tongue during propulsion of the bolus in the oral phase of swallowing compresses sensory receptors in the oropharynx and deep tongue receptors (Dodds, Stewart et al., 1990; Logemann, 1998). Miller (1999) notes the importance of these receptors in the base of the tongue for eliciting the pharyngeal swallow and states that pharyngeal sensation in particular is important for the elicitation of the pharyngeal swallow reflex. Areas of the oral region, pharynx and larynx, including the faucial arches, soft palate, tongue, tonsils, posterior-pharyngeal wall and the base of the tongue contain a myriad of sensory receptors that respond to different types of stimulation (Crary & Groher, 2003; Logemann, 1993; Miller, 1982; Miller, 1999). There are sensory receptors both on the mucosal surface and deep within the muscles themselves (Miller, 1982). These receptors are individually responsive to a range of stimuli including thermal, chemical, nociceptive, and proprioceptive stimuli and all act as distinct endpoints for the sensory nerve fibres (Miller, 1999). This sensory input allows perception of a stimulus and helps to regulate motor responses and thus is essential to the accurate and safe movements of both the tongue and teeth, particularly as these movements relate to swallowing (Dodds, Stewart et al., 1990;

Miller, 1999).

Several cranial nerves are involved in the transmitting of sensory information to the brainstem. The vagus (CN X) and glossopharyngeal (CN IX) nerves convey a large proportion of the sensory information important for swallowing. The trigeminal (CN V) and facial (CN VII) nerves are involved to a lesser extent (Crary & Groher, 2003; Dodds, Stewart et al., 1990; Miller, 1982). The vagus nerve is the most involved cranial nerve for transmitting sensory information relevant to swallowing. It provides sensation to all of the intrinsic muscles of the larynx and the hypopharynx (Dodds, Stewart et al., 1990). The glossopharyngeal nerve provides general sensation and taste to the posterior third of the tongue, tonsils, soft palate and upper pharynx. Taste to the anterior two-thirds of the tongue is regulated by the chorda tympani of the facial nerve, and the facial nerve also contributes sensation to the soft palate and the adjacent pharyngeal wall (Crary & Groher, 2003; Miller, Bieger & Conklin, 1997). The trigeminal nerve provides taste and general sensation to the oral cavity (Crary & Groher, 2003). Of particular importance to the triggering of the pharyngeal swallow is the sensation to the base of tongue which is provided by the vagus nerve (Dodds, Stewart et al., 1990).

The sensory receptors in the tongue, oropharynx and larynx are excited by the bolus and convert the initial stimulus into membrane current charges that are then transmitted towards the central nervous system (Logemann, 1998; Miller et al. 1997; Miller, 1999). The nucleus tractus solitarius (NTS) is the cell body where sensory information is gathered and integrated and is contained within the dorsal medulla of the brainstem (Crary & Groher, 2003; Donner et al., 1985; Miller et al., 1997). Input from each sensory receptor is projected along afferent fibres of the cranial nerves and integrated with concurrent sensory input by the NTS (Miller, 1999). For a stimulus to have an operative effect, it must excite many receptive areas in a sensory fiber group and will have more effect if dynamic in nature rather than static (Miller et al., 1997; Miller, 1999).

The ability of a stimulus to provoke a pharyngeal swallow varies because afferent fibers that provide sensation to the various receptive fields synapse at different locations in the brainstem. Eliciting a swallow requires that the stimulated sensory fibers synapse in a particular neural region (Miller et al., 1997). For example, both the NTS and the trigeminal sensory nuclei receive sensory input but only the sensory input received by the NTS and the adjacent reticular formation will elicit a swallow (Miller et al., 1997). Interestingly, the most ineffective type of stimuli for activating the brainstem central neurons is thermal stimulation (Miller, et al., 1997).

Although much of swallowing activity is controlled by the brainstem, the cortex also has a very important role to play in the organization of swallowing, as demonstrated by the occurrence of dysphagia in patients after cerebrovascular strokes (Daniels & Foundas, 1997; Miller, 1999). The cortex modifies the duration and intensity of the swallowing response (Miller et al., 1997). The actual neuroanatomical mechanisms in the brain that contribute to the cortical control of swallowing are yet to be determined (Daniels & Foundas, 1997; Fujiu, Toleikis, Logemann & Larson, 1994; Miller et al., 1997; Zald & Pardo, 1999). Many researchers have evaluated the cortical mechanisms of swallowing using functional neuroimaging techniques and have found that numerous brain regions are activated during swallowing (e.g. Daniels & Foundas, 1997; Furlong et al., 2004**;** Huckabee, Deecke, Cannito, Gould & Mayr, 2003; Zald & Pardo, 1999). The findings from these studies suggest that a complex neural network exists that contributes to the action of swallowing.

In an early study investigating the role of sensory input in swallowing, Miller (1972) sought to study the effect of systematically deleting a widespread area of sensory innervation on the sequencing of muscle contraction in swallowing. Miller evaluated 26 cats that underwent various combinations of muscle denervation, anaesthesia and paralysis. The findings showed that paralysis and denervation of buccopharyngeal muscles and cranial nerves did not modify the sequence in which these muscles were activated during swallowing. Miller (1972) proposed from these findings that swallowing is controlled by a pre-programmed neuronal network that is independent of constant input from the sensory receptors.

The neural network for swallowing is known as a central pattern generator and is thought to produce a patterned swallowing response which operates according to a pre-set sequence once swallowing is initiated (Dodds, Stewart et al., 1990; Miller, 1982). Although this central pattern generator is thought to be able to produce a swallowing response without continual sensory input once initiated, sensory input is important in modulating the nature of that response (Miller, 1982; Miller, 1999). As Crary and Groher (2003) recognise, "swallowing is best understood as a combination of pre-programmed events with neural circuitry that can adapt to change if needed" (p. 15).

Videofluoroscopic Evaluation of Swallowing

Careful and detailed assessment is the essential initial step in the appropriate management of dysphagia. The videofluoroscopic examination of swallowing has become a highly valued and commonly used tool in the diagnosis, management of and research into dysphagia. The dynamic nature of this tool means that it is able to capture the rapidly occurring physiological components of swallowing (Martin-Harris, Logemann, McMahon, Schleicher & Sandidge, 2000).

A videofluoroscopic swallowing study is performed by viewing a patient via fluoroscopy, with the patient positioned in a lateral view. Often the patient will be viewed in an anterior-to-posterior position also. The patient's swallowing is viewed in real-time as they ingest fluid or food mixed with barium contrast. Although protocols vary between clinical settings, typically the speech-language therapist and radiologist will together evaluate the swallow and formulate a diagnosis. Observations are primarily focused on the oral cavity, pharynx and larynx, though the esophagus may also be viewed to assess for motility and passage of the bolus through to the stomach (Logemann, 1998; McKenzie, 1997).

Due to the complex nature of swallowing, many rating scales have been developed to guide the speech-language therapist through the videofluoroscopic swallowing study and enable the classification of the symptoms observed. One such rating scale is the Videofluorographic Examination of Swallowing, developed by Logemann (1993). In this assessment, the speech-language therapist is directed to view swallowing from both lateral and anterior-to-posterior views. The symptoms are categorised under five phases: preparation to swallow, the oral phase, triggering of the pharyngeal swallow, the pharyngeal phase, and the cervical esophageal phase. Another set of assessment criteria, the NZIMES (Huckabee, manuscript in preparation) is a comprehensive and detailed scale for the videofluoroscopic analysis of swallowing, and is widely used in New Zealand by speech-language therapists. The NZIMES presents a division of swallowing into five main parameters: oral, oral pharyngeal transit, pharyngeal, crico-esophageal and laryngeal. Within each category, the parameters are described and rated from 0 (*no significant impairment*) to 4 (*profound impairment*) with specific criteria describing physiology at each severity level. There have also been a number of other rating scales developed for use with videofluoroscopy, such as those developed by Han, Paik and Park (2001) and Rosenbek, Robbins, Roecker, Coyle and Wood (1996).

The difficulty is that while current videofluoroscopy rating scales are often very descriptive, videofluoroscopy itself as a tool has limitations (McKenzie, 1999; Tabaee et al., 2006). One primary limitation of videofluoroscopy is that it only allows the visualization of biomechanics and structure and does not provide information on the underlying pathophysiology of disordered swallowing, such as whether the dysphagia is a result of a sensory impairment or a motor impairment (McKenzie, 1999; Tabaee et al., 2006). Therefore current videofluoroscopy assessment criteria can only infer information about the nature of neurological damage resulting in the observable symptoms of dysphagia.

Differentiating between Delayed Pharyngeal Swallow and Premature Spillage Secondary to Poor Oro-Lingual Control

The inability of videofluoroscopy to provide information on the underlying pathophysiology of swallowing is particularly problematic when using videofluoroscopy to differentiate between a delayed pharyngeal swallow and premature spillage secondary to poor oro-lingual control. Both physiologic abnormalities result in an identical radiographic sign, that of pre-swallow pooling of the bolus in the pharynx when viewed via videofluoroscopy (Dodds, Logemann & Stewart, 1990; Huckabee & Pelletier, 1999; Logemann, 1993). However, a delayed pharyngeal swallow is caused by a deficit in the relaying and processing of sensory information relating to swallowing whereas premature spillage secondary to poor oro-lingual control is a motor disorder (Huckabee & Pelletier, 1999).

The rating scales currently available for use with videofluoroscopy require the speech-language therapist to make a decision regarding timing of the swallow based on the position and propulsion of the bolus. There are no guidelines specifying how to differentiate between a delayed pharyngeal swallow and premature spillage secondary to poor oral control when both may result in the symptom of pre-swallow pharyngeal pooling.

Delayed Pharyngeal Swallow

Huckabee and Pelletier (1999) describe a delayed pharyngeal swallow as the failure of a coordinated and timely pharyngeal response to occur following a purposeful transfer of the bolus into the pharynx. Logemann (1998) defines the position of the bolus head as the major symptom of a delayed pharyngeal swallow and proposes that a delay is recognized when the “leading edge” (p. 93) of the bolus head has progressed too far into the pharynx before the onset of a pharyngeal swallow. Anterior hyolaryngeal excursion is considered to be the marker of the onset of the pharyngeal swallow (Logemann, 1998).

Determining the position of the bolus head is the most commonly used method of diagnosing a delayed pharyngeal swallow advocated in the dysphagia literature. However, this is a weak basis on which to build a diagnosis that indicates an impairment of sensory function. Bolus position at the onset of swallowing is a symptom of underlying pathophysiology and therefore the sensory response or muscle coordination and function that is ultimately the cause of bolus position should be evaluated, rather than the resulting symptoms. In addition, individual variability between subjects has been shown to be considerable so it is likely that bolus position at the onset of swallow will vary irrespective of the status of swallowing (Gay, Rendell & Spiro, 1994; Kendall, 2002).

Premature Spillage Secondary to Poor Oro-lingual Control

Premature spillage of the bolus secondary to poor oro-lingual control is defined by some or all of the bolus falling over the base of the tongue into the pharynx prior to the onset of swallowing. This can occur during the oral preparatory or the oral phase according to the criteria set out in The Videofluorographic Examination of Swallowing (Logemann, 1993). Within the oral phase on the NZIMES (Huckabee, manuscript in preparation), lingual control and palatal closure are evaluated to assess for the presence of premature spillage. As discussed earlier, although pre-swallow pharyngeal pooling can indicate a disorder of the oral phase caused by poor oral control and lack of an adequate glossopalatal seal, a certain amount of premature spillage of the bolus into the pharynx prior to the onset of the pharyngeal swallow is normal (Dodds, Logemann et al., 1990; Logemann, 1998). Also, the intermittent nature of the glossopalatal seal can make it difficult to determine if there is problem with tongue control (McKenzie, 1997).

Importance of Diagnostic Accuracy

The limitation of videofluoroscopy and the accompanying rating scales discussed above is an important issue in the clinical management of dysphagia because it is not possible to appropriately treat a disorder that has not been accurately diagnosed. Many factors must be taken into consideration when deciding upon a management plan for the person with dysphagia (Crary & Groher, 2003). Rehabilitation and compensation are two separate components of dysphagia management. Compensation can be defined as the use of strategies to improve the safety or efficacy of swallowing in an immediate but usually temporary fashion. That is, compensatory strategies are not expected to have a long-term effect on dysphagia (Huckabee & Pelletier, 1999). Chin-tuck or head-turn strategies are two examples of compensatory strategies. Rehabilitation on the other hand, involves the application of interventions that over time are thought to result in an alteration of underlying swallowing physiology, such as pharyngeal strengthening exercises (Huckabee & Pelletier, 1999). Appropriate management will involve the application of rehabilitation or compensatory techniques dependent upon the underlying physiological disorder. The differentiation between a delayed pharyngeal swallow and premature spillage of the bolus secondary to poor oral-lingual control is one that must be made correctly if a patient with dysphagia is to receive the correct management (Huckabee & Pelletier, 1999; Kaatzke-McDonald, Post & Davis, 1996; Murray, 1999). As Huckabee and Pelletier (1999) state, "…it is crucial that this deficit [delayed pharyngeal swallow] be distinguished diagnostically from premature spillage secondary to poor oral control, a neuromuscular deficit. Although the radiographic image is similar, the management is quite different for each disorder" (p. 37).

Despite this requirement for correct diagnosis, it is only infrequently that the dysphagia literature proposes that the clinician or researcher must exercise care to make this distinction (Huckabee & Pelletier, 1999; Logemann, 1998; Rosenbek, Robbins, Fishback & Levine, 1991). No studies to date have investigated a method of reliably distinguishing between the two disorders. The deficiency in addressing this issue of correctly differentiating between delayed pharyngeal swallow and premature spillage secondary to poor oro-lingual control may have lead to methodological issues in the literature on dysphagia and consequently influenced outcomes of research.

In an early study on the nature and frequency of dysphagia in individuals following cerebrovascular accident (CVA), Veis and Logemann (1985) claimed that a delayed pharyngeal swallow was the most common dysphagic symptom following CVA, occurring in 82% of the 38 subjects studied, and was the most common cause of aspiration. The subjects in this study all presented with dysphagia as a result of a CVA and were examined videofluorographically. Interestingly, delayed pharyngeal swallow is not actually defined by the authors in this study. Veis and Logemann (1985) define oral transit time as the period from when the tongue volitionally transfers the bolus posteriorly until the bolus proceeds over the back of the tongue. The time period from when the bolus passes the back of the tongue until it progresses past the upper esophageal sphincter into the esophagus is defined as pharyngeal transit time. The authors state that the swallowing reflex should occur when the bolus passes over the back of the tongue. One must assume that a delayed pharyngeal swallow is apparent when the bolus has passed the back of the tongue but no swallowing reflex has been elicited.

This infers a definition of delayed pharyngeal swallowing but does not clearly distinguish between a delayed pharyngeal swallow and poor oro-lingual control, which can also result in the some of the bolus passing the back of the tongue and prematurely spilling into the pharynx without the triggering of the swallowing response. The lack of adequate definition of a delayed pharyngeal swallow creates difficulty in replicating this study and casts some doubt on the conclusion that delayed pharyngeal swallow is the most common dysphagic disorder post-stroke, and also the supposed finding that aspiration was caused only by pharyngeal phase dysphagia. It is difficult to conclude with any certainty that the symptoms seen on videofluoroscopy in these subjects were characteristic of a delayed pharyngeal swallow and not actually secondary to poor oro-lingual control.

Stimulation Studies

Delayed pharyngeal swallow remains difficult to treat therapeutically because it is caused by a sensory deficit rather than a deficit of motor control or strength. As knowledge on the sensory pathways of swallowing has accumulated, dysphagia researchers have sought to develop treatments for sensory impairments of swallowing. Consequently, one technique that has become popular for delayed pharyngeal swallow is that of thermal stimulation. Thermal stimulation is known by several different titles in the literature, including thermal application (Rosenbek et al., 1991), tactile-thermal application (Rosenbek et al., 1998; Sciortino, Liss, Case, Gerritsen & Katz, 2003) and thermal-tactile stimulation (Hardy & Morton, 1993). Rosenbek et al. (1991) was careful to use the term *thermal application* rather than *thermal stimulation* in an effort to avoid making an assumption about the effects of this method. Originally described by Logemann (1983) as an indirect therapy for a delayed pharyngeal swallow, thermal stimulation consists of stroking the anterior faucial arches several times with a chilled laryngeal mirror. Logemann (1983) recommended thermal stimulation several times daily for a period of weeks and proposed that the timeliness of swallow onset could be evaluated by palpating the patient’s neck. Adaptations of this technique include chemical stimulation and the use of varied types of mechanical or touch stimulation (Sciortino et al., 2003). The intention of stimulating the oropharynx in this manner is to intensify the sensory input to the brainstem and cortex. This in turn should theoretically result in a more prompt onset of swallow once the bolus is presented (Crary & Groher, 2003; Logemann, 1998).

Studies have demonstrated that the brain does respond to certain types of stimulation. Fraser et al. (2002) conducted a series of experiments using transcranial magnetic stimulation (TMS) to evaluate human cortical motor reorganization following variations in somatosensory input. One purpose of these experiments was to examine the relationship between cortical reorganization and practical clinical rehabilitation of dysphagia. The subjects in these experiments were eight healthy adults with no dysphagia and sixteen adults with acute dysphagia following a first-time CVA. The subjects with dysphagia underwent videofluoroscopy to determine swallowing function. Dysphagia was diagnosed when barium was detected in the airway on videofluoroscopy as a result of disordered bolus flow. Neural conduction was evaluated through the use of TMS and measured by electromyography prior to and following pharyngeal stimulation. Pharyngeal electrodes were used to deliver electrical stimulation via a pharyngeal catheter to the pharynx. The authors found that frequency, intensity and duration of the stimulation had a major influence on the excitability of the corticobulbar projection, and that this change in excitability was functionally relevant to volitional swallowing. The stimulation pattern was found to be an important factor in producing plastic alterations in cortical excitability. The sensorimotor cortex was the predominant area affected by the sensory stimulation and much of the change in the excitability actually occurred in the non-damaged hemisphere of the brain in the dysphagic subjects, indicating a change in swallowing representation in the cortex. Perhaps of most relevance to the practical rehabilitation of swallowing was the finding that electrical stimulation of the pharynx resulted in improved swallow initiation time and decreased occurrence of aspiration in the dysphagic subjects for at least one hour after stimulation. The authors concluded that these experiments support the hypothesis that improved motor function can result from changes to cortical excitability brought about by sensory stimulation.

Fujiu et al. (1994) conducted a study using glossopharyngeal evoked potentials (GPEPs) to evaluate the electrophysiological effects on the central nervous system from mechanically stimulating the anterior faucial pillars. The participants were thirty healthy, young (20-29 years of age) adults. Hemispheric asymmetry was found to be a notable aspect of the evoked potentials measured from the stimulation of the anterior faucial pillars, with the ipsilateral hemisphere to the stimulated pillar exhibiting a greater positive voltage value than the hemisphere on the opposite side from the stimulated pillar. No significant difference was found between the two hemispheres in terms of latency. When topical anaesthesia was applied to a faucial pillar, further stimulation of that same pillar still resulted in GPEPs. The authors suggest that this indicates the presence of deep mechanoreceptors and the importance of these mechanoreceptors to the relaying of sensory information. Anaesthesia did not appear to affect latency. Although GPEPs were evoked by the mechanical stimulation of the faucial pillar, there was considerable variation between the subjects as to their desire or need to swallow in response to the stimulation. Participants were asked to report the sensation elicited when the faucial pillars were stimulated. Only one third of participants reported one or more times that the stimulation elicited a desire to swallow. Fujiu et al. (1994) suggested that this desire to swallow reported by a third of the subjects lends support to the idea proposed by Lazzara, Lazarus and Logemann (1986) that thermal stimulation to the anterior faucial pillars can facilitate triggering of the pharyngeal swallow. However, Fujiu et al. (1994) also report that actual swallowing was rarely elicited despite the mechanical stimulation of the pillars being continuous and lasting for more than one minute. The authors suggest from this observation that individuals respond differently to the same stimulus and that this individual variation may be why thermal application does not appear to be efficacious in all studies.

An early study into the efficacy of thermal stimulation was carried out by Lazzara et al. (1986), although thermal stimulation was at this time already advocated (Logemann, 1983) and in use as a therapy procedure for the problem of a delayed pharyngeal swallow. Lazzara et al. (1986) studied 25 participants who presented with delayed pharyngeal swallowing as a result of neurological impairment. A delayed pharyngeal swallow was identified on videofluoroscopy by observing the bolus fall over the back of the tongue and into the pharynx without initiating a pharyngeal response. This definition fails to differentiate between a delayed pharyngeal swallow and premature spillage secondary to poor oro-lingual control. Each participant was given two boluses of liquid barium and two boluses of barium paste to swallow. Each participant was given thermal stimulation after swallowing the second bolus of each consistency and then given one more bolus of the same consistency. All swallows were viewed via videofluoroscopy. The authors found that triggering of the swallow response was improved in 23 out of 25 participants following thermal stimulation on swallows of at least one of the consistencies given. One of the measures that the authors used to evaluate the change in swallowing was duration of pharyngeal transit, defined as the time from when the bolus passed the back of the tongue until it progressed through the upper esophageal sphincter. It is difficult to see how the authors could ascertain change in pharyngeal transit time after beginning with such an ambiguous definition of a delayed pharyngeal swallow. The authors also used total transit time, defined as the sum of oral transit and pharyngeal transit times. Lazzara et al. (1986) admit that it is difficult to pinpoint the time at which the oral phase ends and the pharyngeal phase is initiated in a person with a delayed pharyngeal swallow and therefore that the measurement of total transit time may not be reliable or consistent. It is also possible that, if the authors were in fact performing thermal stimulation on participants with premature spillage secondary to poor oro-lingual control rather than with delayed pharyngeal swallowing, some of the changes they observed may have actually been improvements in oro-lingual control secondary to the increased oral sensation provided by the thermal stimulation or may have occurred simply because of test effect.

Rosenbek et al. (1991) assessed the impact of thermal application upon swallowing response by applying thermal (cold) stimulation to the anterior faucial pillars of subjects who presented with dysphagia as a result of multiple strokes. Videofluoroscopy was used to evaluate the presentation of the dysphagic symptoms, set a baseline at the beginning of the study and to measure change throughout the intervention process and maintenance one month after conclusion of the treatment. Seven subjects were selected, among other criteria, due to having the symptom of a delayed onset of pharyngeal swallowing response, and were studied using a single-case withdrawal design. The presence of a liquid bolus in the vallecular and/or pyriform sinuses prior to the onset of maximum hyolaryngeal excursion as seen on videofluoroscopy was considered to be sufficient evidence of a delayed pharyngeal response. As with the study by Lazzara et al. (1986), this definition of delayed pharyngeal response does not differentiate between a delayed pharyngeal swallow and the symptom of premature spillage of the bolus into the pharynx secondary to poor oro-lingual control. Interestingly, the authors admit in the discussion that their definition of delay was “liberal” (Rosenbek et al., 1991; p. 34) but do not acknowledge that this could result in confusion between delayed pharyngeal swallow and premature spillage secondary to poor oro-lingual control.

In the Rosenbek et al. (1991) study, three judges determined the effects of the thermal application upon duration and descriptive aspects of swallowing. Duration measurements included evaluation of duration of stage transition (DST). Descriptive measures included judgments about the frequency and severity of dysphagic symptoms. The three judges investigated if (1) swallowing of liquid boluses could be affected by daily thermal application, (2) if the changes resulting from thermal application were maintained one month after the end of the intervention and, (3) whether or not the effects of thermal application could be predicted by baseline testing. Although some variations in swallowing behaviour were observed, the study findings did not provide any reliable support for the use of a period of thermal application to improve a delayed pharyngeal swallowing response. Rosenbek et al. (1991) state that their study does at least lend some support to the use of thermal application for the treatment of dysphagia.

One methodological issue that may have weakened the Rosenbek et al. (1991) study was that subjects were instructed to hold the bolus in their mouths until instructed to swallow. One must query the effect that controlling the onset of swallow could have had on the usual oral transfer of the subjects in this study, especially as the authors state that they are studying spontaneous swallows. There is a bolus control technique used as a compensatory strategy in patients with tachyphagia and delayed pharyngeal swallow called the Three-Second Preparation Technique (Huckabee & Pelletier, 1999)**.** In this technique, the patient is asked to hold the bolus in their mouth for three seconds before initiating the swallow. The rationale behind this technique as a compensatory strategy is that it allows the patient with delayed onset of swallowing time to coordinate the transfer and initiation of the swallow and helps the tachyphagic patient to slow down the rate of intake (Huckabee & Pelletier, 1999).

A further study by Rosenbek, Roecker, Wood and Robbins (1996) sought to establish some data on the variability between and within subjects on measures of DST and total swallow duration (TSD). The authors also examined the effect that thermal application had on these measures of duration. DST was measured as defined by Robbins, Hamilton, Lof and Kempster (1992) as the time period between the head of the bolus passing the posterior margin of the mandible and the onset of maximal hyoid bone elevation. TSD was measured as the time from initial posterior movement of the bolus until the return to rest of the hyoid bone. Twenty-two subjects with dysphagia as a result of stroke were evaluated. Videofluoroscopy was used to measure DST and TSD of the subjects' swallowing with a semi-solid barium paste. Ten consecutive untreated swallows were compared to 10 consecutive swallows with thermal application preceding each one. One finding from this study was that significant variability existed between and within subjects in relation to DST and TSD. Thermal application appeared to result in a decrease in within-subject variability for some but not all subjects. Thermal application also resulted in significantly shorter TSD and DST when compared to the 10 untreated swallows. Rosenbek, Roecker et al. (1996) propose that the variability in measures of duration within subjects presents a challenge to determining the appropriateness of recommending treatments such as thermal application.

The investigation of the efficacy of thermal stimulation has widened to include research on the clinical implications of touch and chemical stimulation and combinations of these types of stimulation with thermal stimulation. However, results have been similar to the studies described above (Kaatzke-McDonald et al., 1996 Logemann, Pauloski, Colangelo, Lazarus, Fujiu & Kahrilas, 1995; Rosenbek et al., 1998; Sciortino et al., 2003). Although there is some evidence to support temporary change in swallowing function following thermal stimulation, overall the results across the literature have been far from conclusive and there is a lack of evidence to support the use of thermal stimulation as a rehabilitative method (Huckabee & Pelletier, 1999; Rosenbek et al., 1991; Rosenbek, Roecker et al., 1996; Sciortino et al., 2003). Sciortino et al. (2003) proposed several possible explanations for the inconclusive findings in the literature including difficulty ensuring adequate chilling of the probe used to administer stimulation and the use of healthy subjects in some studies. Although there clearly remains a myriad of factors that could impact on research outcomes, one factor that is largely overlooked but may contribute to the inconsistencies observed in the thermal stimulation literature is the inadequate definition of delayed pharyngeal swallow described in many studies. Rosenbek, Roecker et al. (1996) allude to this when they acknowledge the possibility that duration of stage transition (DST) may not be an adequate measurement to use when evaluating the treatment effects of thermal stimulation.

The thermal stimulation literature highlights that ambiguity in definitions of swallowing dysfunction on videofluoroscopy must impact upon the speech-language therapist's ability to definitively conclude that a patient presents with a delayed pharyngeal swallow, and thereafter to decide upon a treatment plan. Given that the diagnosis of a delayed pharyngeal swallow essentially identifies a sensory impairment, it is relatively surprising that no studies have compared sensory thresholds obtained from sensory testing with videofluoroscopic data. Tabaee et al. (2006) note the necessity of further research into assessments of swallowing to ensure that management of dysphagia is evidence-based.

A Three-Part Criteria to Differentiate between Delayed Pharyngeal Swallow and Premature Spillage Secondary to Poor Oro-Lingual Control

The purpose of this study is to evaluate the clinical validity of three radiographic features for diagnosing a delayed pharyngeal swallow. This study will compare the results of a three-part criteria used to evaluate videofluoroscopic swallowing studies with sensory thresholds obtained from faucial pillar sensory testing to determine if it is possible to predict a sensory deficit based upon a diagnosis of delayed pharyngeal swallowing as determined on videofluoroscopy.

Three criteria will be evaluated: the first part of the criteria involves determining the presence or absence of a reliable glossopalatal seal on videofluoroscopy. As discussed previously, although there is some discussion in the literature regarding the intermittent nature of the glossopalatal seal, it is considered to be an important part of normal swallowing. The purpose of the glossopalatal seal is to maintain the bolus within the oral cavity prior to a propulsive oral transfer of the bolus by the tongue. A poor glossopalatal seal would likely present as premature spillage of the bolus into the pharynx, indicating a disorder of motor control rather than a sensory deficit. A reliable glossopalatal seal will be identified in this study when the posterior portion of the tongue is raised up so that it approximates the lowered soft palate in a consistent manner. It is hypothesized that those participants that present with pre-swallow pharyngeal pooling in the presence of a reliable glossopalatal seal will be shown to have a sensory impairment.

The second criterion to be evaluated is the “drop-push” propulsive movement of the tongue prior to pre-swallow pharyngeal pooling. The term “drop-push” has been chosen to describe the downward movement (drop) of the base of the tongue and the propelling movement (push) of the anterior two-thirds of the tongue against the palate to propel the bolus into the pharynx. It is hypothesized that participants who demonstrate a clear drop-push of the tongue prior to pre-swallow pooling will be shown to have a sensory impairment.

The cohesiveness of the bolus is the third criterion under evaluation in this study. The cohesiveness of bolus transfer was chosen because poor oro-lingual control causing pre-swallow pharyngeal pooling is likely to result in small amounts of the bolus falling over the back of the tongue into the pharynx. Delayed pharyngeal swallow on the other hand is likely to present as a fairly cohesive bolus as a person with adequate oro-lingual control will gather food or fluid into a cohesive bolus and then propel this bolus out of the oral cavity by the drop-push movement of the tongue. Therefore one would expect to see a cohesive bolus in the presence of delayed pharyngeal swallow or a bolus spread throughout the pharynx if occurring as a result of poor oro-lingual control.

Methodology

The participant data (videofluoroscopic swallowing studies and sensory thresholds) for this study originated from research conducted by Dr. Maxine Power (Hope Hospital, Salford, United Kingdom). Dr. Power generously permitted the re-analysis of the data for the purposes of this study and thus the methods below summarise the means of original data collection.

Participants

Stroke patients were recruited from hospital wards and were evaluated within two weeks of the stroke (range 6-13 days, mean 10 days). Patients with a previous history of swallowing impairment, neurological disease, upper gastrointestinal disease or co-occurring illness were excluded from this study. Patients were also excluded if receptive aphasia or cognitive impairment prohibited them from giving informed consent.

In the original data collection, swallowing and sensation were evaluated in 41 patients after stroke. For the current study, 11 patients were excluded from the study due to missing data and one patient was excluded as excessive head movement during the videofluoroscopic swallowing study prevented clear visualisation of the criteria under evaluation. 29 participants (17 male, 12 female, mean age of 70 years, range 44-85 years) in total were evaluated for this study.

Assessment of swallowing

A Siemens Fluorospot® H SIRESKOP SX Unit (Siemens Aktiengesellschaft Medical Engineering, Erlangen, Germany) was used to carry out the videofluoroscopy. A Videomed DI TV system was used to obtain x-ray images in real time. The x-ray images were recorded using digital video (Sony DHR 1000, Sony UK Limited, Weybridge, Surrey, United Kingdom) and stored on digital cassette tape (Panasonic UK Limited, Bracknell, Berkshire, United Kingdom). Continuous fluoroscopy was used to acquire the digitised images. Using a configuration of 1024 x 1024 with 10 bits per pixel allowed for 1023 increments on a grey scale.

Manufacturers recommendations for thin liquid (60%w/v) was used to prepare the barium sulphate liquid (EZ-HD®, E-Z-EM Limited, London, United Kingdom). The barium was put in a Kapitex ™ beaker (Kapitex Limited, Slough, United Kingdom) following measurement. Prior to screening the participants were given a 2ml bolus of barium liquid to accustom them to the taste. Once screening began, participants were given one bolus at a time and instructed to hold the barium in their mouth until given the instruction to swallow. The videofluoroscopic images were then acquired without magnification until the bolus had passed the upper margin of the thoracic oesophagus. Images were acquired in the lateral position. In all cases, the total screening time was restricted to below 80 seconds (range of 42-73 seconds), resulting in radiation exposure of <0.3 m Sv.

Assessment of Faucial Pillar Sensation

To establish faucial pillar sensation, a 2mm fingertip electrode (St Marks Pudendal Electrode, Medtronic Diagnostics A/S, Tonsbakken, Denmark) was positioned digitally onto each faucial pillar. A constant current stimulator (Model DS7, Digitimer Limited, Welwyn Garden City, Hertsfordshire, United Kingdom) was connected to each electrode. A trigger generator (Model DG2, Digitimer Limited, Hertfordshire, United Kingdom) conveyed the stimuli at a frequency of 5Hz (square wave duration 200μs). The stimulus intensity delivered to each faucial pillar was increased in a stepwise manner in amounts of 0.2mA from zero until the participant just discerned the electrical sensation. The right and left faucial pillars were stimulated in this manner three times per side in random order.

Analysis of Videofluoroscopic Data Specific to the Current Study

Although the target was for six swallows per participant, some participants were unable to complete the six swallows due to significant aspiration requiring termination of the study. Some swallows were not evaluated because patient positioning prohibited clear evaluation of the set criteria. In total, 165 swallows were available for analysis. The average number of swallows per participant was 5.7.

The digital files were transferred onto DVD (Imation Corporation, Oakdale, Minnesota, United States); Windows Media Player (Microsoft Corporation, Redmond, Washington, United States) was used to analyse the studies because it allowed for frame-by-frame analysis. Each intake of a presented bolus into the mouth was counted as a single swallow for the purposes of this study. Where the participant took several swallows to clear the bolus from the oral cavity, the overall impression for that particular bolus was rated, or, in the case of pre-swallow pooling, the deepest level of pooling was rated.

Each swallow for each participant was first evaluated according to presence or absence of pre-swallow pooling in the pharynx. As pre-swallow pooling is the primary indicator on videofluoroscopy of both premature spillage secondary to poor oro-lingual control and of delayed pharyngeal swallow, those swallows without pre-swallow pooling were not further evaluated. If pre-swallow pooling was observed, the level to which the pooling reached was rated as 1) to the valleculae, 2) to within the lateral channels, or 3) to the pyriform sinuses

Those swallows exhibiting pre-swallow pooling were then analysed according to three criteria. The three criteria evaluated were, 1) There is reliable approximation between the soft palate and base of tongue prior to onset of swallow, 2) There is a definitive drop-push propulsive movement of the base of tongue to transfer the bolus from the oral cavity prior to pre-swallow pharyngeal pooling, and 3) The bolus transfers as a cohesive unit. Each criterion was evaluated using a 5 point Likert scale, with 1 representing "Not At All' and 5 representing "Definitely." Swallows achieving a high score on the scale would reflect physiology considered to be characteristic of the physiologic abnormality of delayed pharyngeal swallow.

Data analysis

The maximum achievable score for each of the three criteria was calculated by multiplying the total number of swallows per participant by 5 (the highest scale score). For example, if a participant had five swallows available for analysis, their maximum achievable score for each of the three criteria would be 25. The sum of each of the three criteria over all the swallows of each participant was divided by the maximum achievable total to obtain a confidence quotient for delayed pharyngeal swallow. The confidence quotient was presented as a percentage score for each criterion to represent the certainty with which the author felt each criterion indicated a delayed pharyngeal swallow for that participant. The overall sensory threshold was determined by calculating the mean of the three stimulations per side of the faucial pillars.

Reliability

Intra-rater reliability—six (21%) of the studies were re-analysed by the author. An additional six (21%) of the studies were analysed by an independent judge to assess inter-rater reliability.

Statistical analysis

Inter and intra-rater reliability data were analysed using intraclass correlation coefficient (ICC). To evaluate the stated hypotheses, the confidence quotient score for each of the three criteria for each participant was converted from a percentage to a whole number and a statistical analysis of correlation was performed using a Pearson product-moment correlation. Each of the three criteria were analysed separately to determine if a correlation existed between the confidence quotient of each criterion and the mean sensory threshold rating of each participant. The alpha level chosen was .05 and all participants were evaluated (N=29).

Results

Intra-rater reliability

Adequate reliability was achieved for presence of pooling (ICC = .97) and the level of pooling (ICC = .95). Criterion one (glossopalatal seal) and criterion three (cohesiveness of bolus) also achieved adequate reliability with ICC = .92 and ICC = .90 respectively, however reliability for criterion two (drop-push) was slightly less than adequate (ICC = .77).

Inter-rater reliability

Inter-rater reliability was poor for presence of pooling (ICC = .68), the level of pooling (ICC = .59) and criterion two (ICC = .20). Criterion one (ICC = .90) and criterion three (ICC = .96) achieved adequate inter-rater reliability.

Three-part criteria

Hypothesis One: There will be a positive correlation between the confidence quotient score for criterion 1 (glossopalatal seal) and sensory threshold. Contrary to the hypothesis, there was no significant relationship between a reliable glossopalatal seal prior to pre-swallow pharyngeal pooling and a high sensory threshold. The correlation coefficient was $r = - .322$ ($p > .05$).

Hypothesis Two: There will be a positive correlation between the confidence quotient score for criterion two (drop-push propulsive movement of the tongue prior to pre-swallow pooling) and sensory threshold. The correlation coefficient ($r = - .234$, $p > .05$) demonstrated no significant relationship between a drop-push propulsive movement of the tongue prior to pre-swallow pharyngeal pooling and a high sensory threshold.

Hypothesis Three: There will be a positive correlation between the confidence quotient for criterion three (cohesive transfer of the bolus) and sensory threshold. The correlation coefficient ($r = - .219$, $p > .05$) did not support a relationship between the cohesiveness of bolus transfer and a high sensory threshold.

Discussion

The results do not support the validity of the proposed three-part criteria to differentiate between the symptoms of delayed pharyngeal swallow and premature spillage secondary to poor oro-lingual control on videofluoroscopy.

Three-part criteria

Pre-Swallow Pharyngeal Pooling

Pre-swallow pharyngeal pooling can occur secondary to a delayed pharyngeal swallow or may result from poor oro-lingual control (Huckabee & Pelletier, 1999). Accordingly, the presence or absence of pre-swallow pooling was determined as the preliminary step to analysing the videofluoroscopic swallowing studies using the proposed three-part criteria. Inter-rater reliability for presence and level of pre-swallow pharyngeal pooling was found to be poor in this study, however intra-rater reliability was adequate, indicating that the definition of pre-swallow pharyngeal pooling used in this study was not sufficiently specific. Guidelines specifying anatomical markers for the levels of classification (valleculae, lateral channels and pyriform sinuses) were not defined and it may have improved inter-rater reliability on the measures of both presence and level of pre-swallow pharyngeal pooling if they had been. It is worth noting that the interpretation of the symptom of pre-swallow pharyngeal pooling probably varies considerably across the field of dysphagia practice and research based on these inter-rater reliability results. If pre-swallow pharyngeal pooling cannot be reliably identified by independent clinicians or researchers, this has implications for the validity of pre-swallow pooling as an indicator of impairment.

The validity of pre-swallow pharyngeal pooling is an issue further complicated by the knowledge that, in normal swallowing, some pre-swallow pharyngeal pooling is known to occur during the oral preparatory phase with boluses that require mastication (Hiiemae & Palmer, 1999; Logemann, 1993; McKenzie, 1997). In the current study, only swallows of liquid boluses were available for analysis. Therefore, any pre-swallow pharyngeal pooling observed during analysis should have been indicative of impairment. But regardless of bolus texture, caution needs to be taken in assuming that any pre-swallow pooling during the oral preparatory phase is a normal occurrence following stroke. The study by Dua et al. (1997) on the relationship between bolus transit and airway protection reported considerable pharyngeal pooling prior to the onset of swallowing but used only young, healthy participants. The implications of comparing healthy participants to those with neurological damage will be considered later in this discussion.

Glossopalatal Seal

Following the identification of pre-swallow pharyngeal pooling, the reliability of the glossopalatal seal was evaluated. During the analysis of the participants' swallows, it became apparent that this is an observation which can be difficult to categorize. As noted by McKenzie (1997), the glossopalatal seal is intermittent, although it should be consistent enough with liquid boluses to prevent premature spillage of the bolus into the pharynx. It was difficult to assess the reliability of the glossopalatal seal when, despite inconsistent tongue-to-palate approximation, there was no premature spillage of the bolus into the pharynx. A glossopalatal seal that is inconsistent with liquid boluses could be indicative of minor impairment or could alternatively be within the normal range. However, it was possible to identify a glossopalatal seal that was notably disordered. Used in conjunction with other measures, this criterion is still a worthwhile indicator in the differentiation between delayed pharyngeal swallow and premature spillage secondary to poor oro-lingual control.

Drop-Push Tongue Movement

The second criterion to be evaluated was the drop-push propulsive movement of the tongue to transfer the bolus from the oral cavity into the pharynx. The reliable identification of a drop-push movement of the tongue prior to pre-swallow pharyngeal pooling proved problematic both for intra-rater and inter-rater-reliability. The evaluation of only thin liquid boluses may have been a limitation in the evaluation of this criterion. The drop-push movement of the tongue is likely to be less distinct with liquids as less propulsive force is required to transfer a thin liquid bolus into the pharynx than a bolus of a thicker consistency (Youmans & Stierwalt, 2006). The use of thicker liquids or more solid boluses may have enabled clearer visualisation of the drop-push movement of the tongue.

The majority of literature that refers to the diagnosis of a delayed pharyngeal swallow advocates the position of the bolus, particularly the position of the bolus head, at the onset of the swallow as the marker of delay. However, as already discussed, bolus position is subject to a number of variables that preclude it from being a reliable indicator of delay. As the drop-push propulsive movement of the tongue is the primary source of bolus movement, there remains some cause to advocate that the timing of this tongue movement in relation to swallowing onset should be further investigated as a marker of delayed pharyngeal swallow.

Cohesiveness

The cohesiveness of the bolus was the third criterion to be evaluated. The potential to fully assess the efficacy of this criterion was limited because only liquid swallows were available for analysis from the original data pool. Because of their consistency, liquids are more likely to spread throughout the pharynx than thicker or more solid textures when pooling pre-swallow. Therefore it was difficult to establish exactly how cohesive bolus transfer actually was. Cohesiveness of bolus transfer would have been more apparent if solid consistencies had also been evaluated.

The Relevance of Faucial Pillar Sensation to Swallowing

The method used to ascertain sensory thresholds in this study was the electrical stimulation of the faucial pillars. The relevance of faucial pillar sensation to the elicitation of swallowing has come into question in a recently published study by Power et al. (2006) and may be a significant factor contributing to the findings observed in the current study.

Power et al. (2006) evaluated the effects of faucial pillar stimulation on swallowing and aspiration in stroke patients with dysphagia. Sixteen participants with dysphagia following hemispheric stroke were evaluated. Swallowing was assessed via videofluoroscopy and measured according to oral transit time, pharyngeal transit time and swallow response time. Sensation was evaluated by using a fingertip electrode to stimulate each anterior faucial pillar until the participant just detected the stimulus. Aspiration was measured using the Aspiration-Penetration Scale (Rosenbek, Robbins et al., 1996). Participants were randomly selected to receive either faucial pillar stimulation of 0.2-Hz or sham faucial pillar stimulation. The results of the study showed no changes in any of the measures of swallowing performance or aspiration following either anterior faucial pillar stimulation or sham stimulation. Power et al. (2006) suggest that one reason for the findings in their study is that the faucial pillar region may not be a relevant sensory field for eliciting swallowing.

Power et al. (2006) state that to postulate that faucial pillar stimulation is relevant to the initiation of the swallowing reflex is dependent upon two important assumptions; 1) that the physiological components responsible for relaying sensory information to the swallowing centers are intact and 2), that oral (faucial pillar) stimulation initiates the swallowing response.

Many studies evaluating the relationship of faucial pillar sensation to swallowing, such as those by Fujiu et al. (1994), Kaatzke-McDonald et al. (1997) and Pommerenke (1928), have used healthy participants as opposed to those with neurological impairment. The participants in the current study all presented with dysphagia following stroke. It is not known how the physiological make-up of swallowing may adapt to compensate for damage to neural control. While faucial pillar stimulation may be sufficient to initiate swallowing in healthy participants, other areas of the oropharynx may become more relevant to the initiation of swallowing in the person with neurological damage.

As other research has indicated, sensation to many different areas of the oropharynx is important to swallowing (Dua et al., 1997). Pommerenke (1928) proposed that no one single area is able to elicit the swallowing response in isolation. In the current study, the mismatch between observed physiology on videofluoroscopy and the sensory thresholds obtained from testing of the faucial pillars may indicate that the faucial pillars are not the most appropriate indicator of sensation relevant to swallowing regardless of the neurological status of the individual. An impairment of faucial pillar sensation, or in fact of any one area of the pharynx, may not indicate an impairment of overall sensation as it pertains to swallowing. Thus, the results of this study may be a consequence of inadequate sensory testing rather than suggesting that the three-part criteria is invalid.

Individual variability

If faucial pillar sensation is variable between participants as suggested by Fujiu et al. (1994), this may also have contributed to the results of the current study. Other research has shown that there is considerable inter-participant variability in terms of swallowing pattern and timing in healthy individuals, particularly as an effect of age (Kendall, 2002; Robbins et al., 1992), so it is reasonable to assume that oropharyngeal sensitivity as it relates to the onset of swallowing may also vary. The gag reflex is an example of inter-participant sensation variability as it has been shown to not be present in all healthy individuals (Miller, 1999).

Co-Existence of Motor and Sensory Deficits

Many people presenting with dysphagia as a result of neurological damage are likely to have both a sensory and a motor component to their dysphagia (Huckabee & Pelletier, 1999). Certainly in the analysis of the videofluoroscopic data for this study it was evident that many participants appeared to present with symptoms of both poor oro-lingual control and a delayed onset of the pharyngeal swallow. Subjectively however, it appeared that there was often a pattern of swallowing that tended to either the appearance of a delayed pharyngeal swallow indicative of a sensory deficit or to the motor impairment of poor oro-lingual control. The tendency of individuals to present with symptoms of both motor and sensory impairment may impact on the effectiveness of any criteria to definitively diagnose one or the other.

Conclusion

Although the findings from this study were not significant, the issues raised are critical to clinical practice and future research. This study has attempted to address the inadequacy of videofluoroscopy rating scales in the differentiation between motor and sensory impairments. While it is not a simple issue, it is concerning that so little attention has been given to this important problem of diagnosis. As demonstrated in this study, the use of videofluoroscopy to differentially diagnose between delayed pharyngeal swallow and pre-swallow pooling secondary to poor oro-lingual control is complicated by a number of variables. However, it is imperative that motor and sensory deficits are accurately differentiated between if research into thermal stimulation and other dysphagia management techniques are to be efficacious.

Future research comparing this three-part criteria with sensory thresholds obtained from other areas of the oropharynx relevant to initiating the swallowing response, using techniques such as air pulse stimulation (as advocated by Aviv, Martin, Keen, Debell & Blitzer, 1993), would be useful in taking this issue of diagnostic accuracy forward. In addition, clearer definition of terms and the use of a range of bolus consistencies would assist in assessing the validity and reliability of the three-part criteria.

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