The Therapeutic Swallowing Study

M. Bülow

Contents

M. Bülow, SLP, Ph.D.
VO, BoF, Skåne University Hospital, SUS, Malmö, Sweden
e-mail: margareta.bulow@med.lu.se

1 Introduction

When selecting an instrumental procedure to assess oral and pharyngeal swallowing dysfunction videoradiography is the only technique where the entire swallowing sequence could be analyzed (Donner 1988; Jones and Donner 1989; Ekberg 1990, 1992; Dodds et al. 1990a, b; Bingjie et al. 2010; Pisegna and Langmore 2016; Nordin et al. 2017). Accordingly this is an excellent tool for the dysphagia therapist in the management of dysphagic patients.

The videofluoroscopic swallowing study (VFSS) is also referred to as the modified barium swallow study (MBSS) and has been shown to have high clinical yield (Martin-Harris et al. 2000; Gates et al. 2006; Martin-Harris and Jones 2008). Because of the therapeutic implications of the swallowing study, as well as the therapeutic approaches that can be applied and tested during the examination, the study will be described as "the therapeutic swallowing study—TVSS" in this chapter. The therapeutic swallowing study permits observation of upper aerodigestive tract function as the patient swallows varied volumes and textures of different radiopaque materials (Logemann 1986). It has been showed that VFSS protocols using foods with different consistencies would be valuable before recommending normal diet for patients suffering from stroke or other brain injuries (Kang et al. 2011). For accurate and reliable implementation and

Med Radiol Diagn Imaging (2017)
DOI 10.1007/174_2017_89, © Springer International Publishing AG
Published Online: 01 September 2017

interpretation of test results specialized training is required (Logemann et al. 2000).

During the TVSS digital technique is most often used and the entire examination could be recorded on a dynamic medium such as videotape or computer disk making it possible to analyze structural movements in relation to contrast flow in slow motion and frame by frame. However, nowadays digital radiography, i.e., different high-resolution videofluoroscopic recording devices, is used in most radiological departments. The examination could then be transmitted digitally to an electronic picture archiving and communication system (PACS) to provide rapid retrieval and analyses of the entire swallowing sequence. The availability is excellent and easy to handle and any pathophysiology could be analyzed in detail related to the flow of different given textures. For example disordered timing and coordination of structural movement, and the presence, degree, timing, and cause of aspiration, can be documented.

The therapeutic swallowing study is a dynamic procedure that examines the mechanical passage of food and liquid from the mouth to the stomach. However, in most studies the focus lies on oral and pharyngeal phases of deglutition. Comprehensive examination includes the observation of oral bolus manipulation, lingual motility efficiency of mastication, timing of pharyngeal swallow initiation, soft palate elevation and retraction, tongue base retraction, pharyngeal contraction, superior and anterior hyolaryngeal movement, epiglottic inversion, and extent and duration of pharyngoesophageal segment opening (Martin-Harris et al. 2000).

Martin Harris et al. have developed a new modified barium swallow study tool, the Modified Barium Swallow Impairment Profile, or MBSImP, that has "demonstrated clinical practicality, favourable inter- and intrarater reliability following standardized training, content, and external validity" (Martin Harris et al. 2008). "The MBS ImP technique is described as an evidence-based, standardization of the MBS study in adults. The MBSImP assesses 17 critical components of swallowing and provides an objective profile of the physiologic impairment affecting adult swallowing function. For the first time, the MBSImP provides the means for clinicians to communicate MBS study results in a standardized, evidence based manner that is consistent, specific, and accurate" (Shaw Bonilha et al. 2013).

Various therapeutic strategies, such as postural techniques, maneuvers, and techniques improving oral sensory awareness, can be systematically applied and tested and their effect on function can be observed (Ekberg 1986; Logemann et al. 1989; Martin et al. 1993; Martin 1994; Bülow et al. 2001). Different materials are given to the patient to identify optimal food and liquid textures that facilitate a safe and efficient oral intake.

Clinical experience and research findings provide evidence that aspiration, and more importantly the cause of aspiration, can be missed during observations made from test swallows included in a clinical or bedside examination. Studies have shown that clinicians do not consistently identify the presence of aspiration during clinical examinations. The sensitivity and specificity of the bedside examination in detecting aspiration and in predicting patient outcome warrant further study. Furthermore, it has been reported that 50–60% of patients who aspirate do not cough (Linden and Sibens 1983; Splaingard et al. 1988; De Pippo et al. 1992; Nathadwarawala et al. 1992, 1994; Zenner et al. 1995; Miller et al. 2014; Jaffer et al. 2015).

Despite its limitations, the bedside or noninstrumental examination provides important information regarding signs and symptoms of potential swallowing disorders and need for further instrumental examination, impressions regarding the patient's language and cognitive status, propensity for fatigue during eating and drinking, and a realistic picture of the patient's eating and drinking patterns.

2 How to Perform the Study

At the radiological department of Skåne University Hospital, SUS, Malmö, Sweden, we started our examinations in 1993, and have now almost 25 years of experience. Our swallowing assessment team includes collaboration between speech/language pathologists and radiologists in the performance and analysis of the therapeutic swallowing study. We perform our studies twice a week, and have the opportunity to schedule at least 10–12 patients every week. The teamwork of the two specialists provides rapid and adequate information about current swallowing dysfunction and management recommendations to the referring clinician, patient, and caregivers.

The swallowing recording equipment includes:

- **Digital technique** (Philips multidiagnost ELEVA)
- Sectra (RIS, PACS)
- PACS (picture archiving and communication system)
- **Microphone**
  Another equipment mostly used in swallowing research is the KAY Pentax 72 45 C, swallowing work station.

The patient is administered controlled food and liquid textures that are mixed with contrast resulting in a simulated diet but dense enough to allow X-ray visualization. Typically, barium sulfate is used and allows for optimal visualization of bolus passage through the alimentary tract (Murray 1999). However, the sensory properties of food may be affected by adding barium sulfate (Ekberg et al. 2009; Stokely et al. 2014). In another study the importance of rheologically matched test materials is discussed (Groher et al. 2006).

The procedure is most often performed with the patient seated in an upright position (Fig. 1). If the individual is unable to assume and maintain a seating position, adaptive seating devices can be employed. If such devices are not available, the patient may be placed on the fluoroscopic table and the examination is performed with the patient lying down. The head and trunk can then be raised to a semi-upright position. The individual can also be positioned seated in his/her own wheelchair if there is adequate distance between the floor and fluoroscopic tube to permit oropharyngeal and cervical esophageal viewing.

Fig. 1 The laboratory with a patient in an upright position

The study typically begins with the subject in lateral view, the optimal position for visualizing penetration or aspiration of material into the laryngeal vestibule before, during, and after swallowing. In lateral view the profile contours of the soft palate, base of the tongue, posterior pharyngeal wall, epiglottis, aryepiglottic folds, anterior hypopharyngeal wall, and the region of the cricopharyngeal muscle or pharyngoesophageal segment can be assessed. The patient is then positioned in a frontal view permitting assessment regarding asymmetric contours, surface of the base of the tongue, median and lateral glossoepiglottic folds, tonsillar fossa, valleculae, and hypopharynx (Fig. 2).

In our experience the amount of radiation during the study is low, 2–5 mSv (absorbed dose), which is about one-eighth of the amount when performing a colon examination. The average radiation exposure time is 2–3 min. Radiation dose in videofluoroscopic swallow studies was studied in the UK by Zammit-Maempel et al. (2007). They concluded that videofluoroscopy could be performed using minimal radiation dose. Their data is based on the largest number of videofluoroscopic swallowing studies published to date. In another study from 2013 it was found that a standardized protocol for MBSS did not cause unnecessary radiation exposure time during the MBSS (Bonilha et al. 2013).

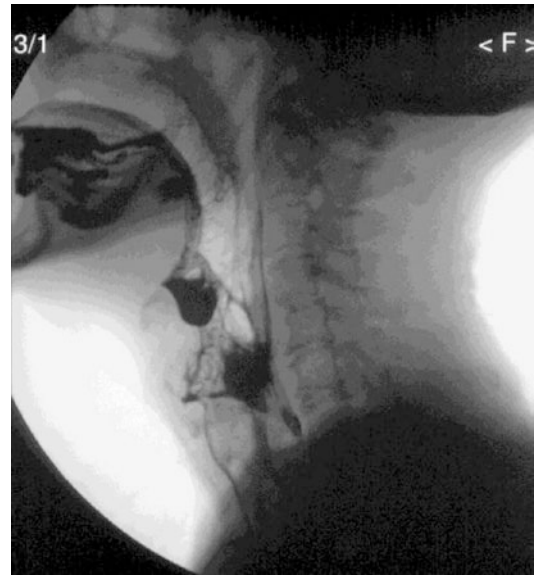

Fig. 2 The lateral radiograph illustrates a tracheal penetration and residue in valleculae and pyriform sinus secondary to a brain-stem stroke

It is critical and of importance that caregivers, nurses (e.g., depending on the medical status of the patient), and/or family members could be present and observe the study either at the time of the examination or at a later viewing of the recorded examination. This provides the opportunity to educate the caregivers in the nature of the patient's swallowing problem, and the necessary precautions and management strategies that must be applied to ensure airway protection and efficient oral intake.

3 Routines During the Study

If possible the patient has to fill in a self-report instrument before the examination. At our clinic we use a validated version in Swedish of Sidney Swallowing Questionnaire (SSQ) (Arenaz Búa and Bülow 2014). During the examnation we complete one of our swallowing protocols. Which one depends on the specific examination (Tables 2 and 3).

The Swallowing Pathologist

- Decides how the procedure will be performed based on actual referral or from observations of the patient during a bedside examination. The volumes and textures of contrast materials used in the study should be tailored to meet the particular needs of the patient based on his/her clinical swallowing presentation.
- Selects contrast materials (mixing, measured volumes, order).
- Talks to the patient before the examination, and if possible asks for actual symptoms, and gives information about the examination.
- Systematically applies trial therapeutic strategies based on the observed nature of the swallowing disorder.
- Completes the swallowing protocol during the procedure.
- Documents a collaborative report. If necessary together with the radiologist. The report includes recommendations for nonoral intake, appropriate food/liquid textures and bolus volumes, and necessary therapeutic strategies such as compensatory postures, maneuvers, and exercises.

The Radiologist

- Operates the fluoroscopic equipment and observes anatomic abnormalities.
- Documents a collaborative report with the swallowing therapist.

The Assistant Nurse

- Prepares the fluoroscopy suite for the study.
- Prepares the appropriate test material, and administers the material to the patient.
- Completes the registration and operates the videotape recorder.
- Assists the patient before and after the study.

4 Test Material

Every procedure is individually adapted to the patient, even if the same routines are used. If there is a suspicion of aspiration and/or we do not know for sure whether the patient will initiate a pharyngeal swallow, the procedure starts with 2 or 3 mL of water-soluble contrast either as thin or thickened liquid. The patient may not be exposed to any risk of severe aspiration.

The normal procedure consists of the following consistencies (Fig. 3a and b):

- **Pudding** (made from berries)
- **Timbale** (smooth consistency, fish, meat, or vegetables)
- **Sorbet** (sour and cold)
- **Paté** (corny consistency)
- **Chopped solid material** (normal food chopped into small pieces; either meat, fish, or vegetables in sauce.)
- **Thickened liquid**

  Thickened liquid is made fruit puré.

- **Carbonated liquid**

  The carbonated liquid is prepared with tap water and a soda stream machine.

- **Thin liquid**

  See Table 1 for the test material recipe.

From many years of clinical experience we have learned that the amount of contrast mixed with the different materials, solids or liquids, should be 60% test material and 40% contrast.

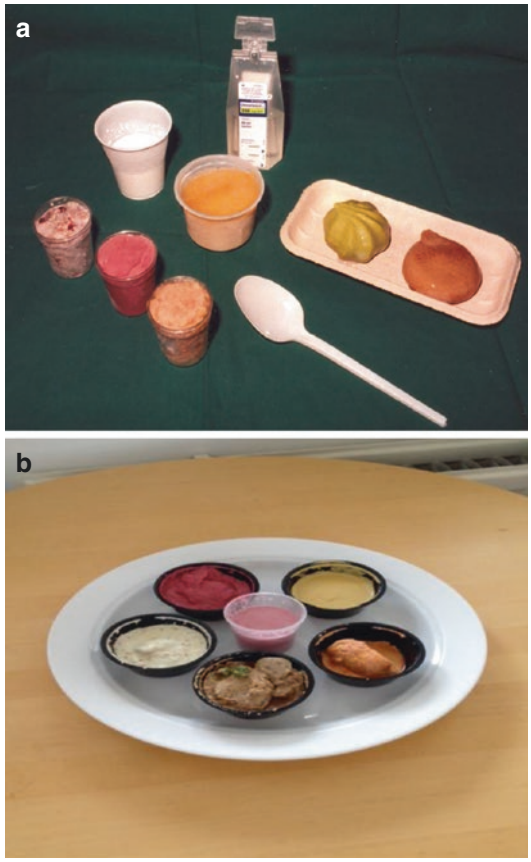

Fig. 3 Test material

Table 1 Recipe of material for the therapeutic swallowing study

• 1 Portion solid bolus consists of 45 g product and 15 g of E- Z-HD barium sulfate for suspension and gives 60 g ready-mixed material (0.5 dL)
• 1 Portion thickened liquid consists of 100 g product and 30 g of E- Z-HD barium sulfate for suspension and gives 130 g ready-mixed material (1 dL). Each dose on 5 mL has a weight of 5 g.
• 1 Portion of thin liquid consists of E- Z-HD barium sulfate for suspension 40% w/w
• 1 Portion carbonated liquid consists of tap water mixed in a soda stream machine. 400 mL of carbonated water is mixed with 100 mL (2 × 50 mL) Omnipaque 350 (350 = mg iodine per mL liquid) just before it has to be used, and should be served cold

Another important observation after analyzing thousands of patients with swallowing dysfunction is that most patients do not need to be recommended several grades of thickened liquids. Our protocol consists of one thick liquid and carbonated liquid. Several different thickened liquids may be confusing for the patient, and may not be easy to handle and use.

When testing mastication some sort of crisp bread covered with barium paste could be used.

Most test material is, if possible, given two times in various amounts from 3 mL, 5 mL, to 10 mL or more. However, depending on the severity of the swallowing impairment and degree of aspiration water-soluble contrast may be used. The patients are fed by the assistant nurse but may if possible also feed themselves, giving important information about their habitual eating and drinking behaviors. However, if nursing staff or significant others are present at the examination they could feed the patient.

Patients suffering from right hemispheric damage often take excessive amounts of solids and liquids during mealtime. This is an important behavior to identify and modify. Studies showing typical bolus volume during thin-liquid swallows indicate that the average volume habitually ingested by males is 21.3–29.3 mL and 13.6–20.4 mL in females (Adnerhill et al. 1989). If the patient wishes, or if he/she reports symptoms with only very specific food or liquid items, he/she may bring material to the examination where it will be mixed with barium contrast and tested.

The test material used in our clinic is prepared by a master chef working at a nursing home, and thereby experienced in cooking for elderly persons with special need of modified textures. In our opinion individuals coming for a TVSS examination, in most cases elderly persons, should get the same food as they are used to. So therefore, food well known for most persons, and therefore easy to recognize, are given to our patients. The only difference is that the test material is food mixed with contrast, either barium sulfate or iodine contrast, in small amounts. However, even if today it is possible to buy readymade test meals from the food industry we have learned that it is of importance for our patients to feel comfortable, and be familiar with the food they get during the examination.

When the test material comes to the radiological department in small cans, 0.5 dL for a solid bolus and 1 dL for thickened liquids, it is placed in a freezer. Before every assessment the assistant nurse takes it from the freezer in time for the study. Every patient gets his/her individual combination of test material depending on the nature of the swallowing problem (Tables 2, 3 and 4).

Table 2 Protocol for therapeutic videoradiographic swallowing examination

Therapeutic Videoradiographic Swallowing Study (TVSS) Date:_____ Radiologist SLP Name:_____Person number: Actual status:_____ Referral _____									
Lateral view	2	10	Independent	Oral dysfunction	Delayed	Absent	Pharyngeal	Penetration	Rosenbek Penetration/ aspiration scale
	3	15	Has to be fed		Pharyngeal swallow	Pharyngeal swallow	Retention	Subepiglottic	
	5 mL	20 mL	Syringe				Mild	Supraglottic tracheal	
							Moderate		
							Severe		
Solids (smooth consistency)									
Sorbet									
Timbale (smooth consistency)									
Paté (corny consistency)									
Hackad kost									
Regular food									
Thin liquid									
Thickened liquid									
Carbonated liquid (soda stream)									
Water-soluble contrast									
Bread									
Other									

Therapeutic strategies
Sensory stimulation:
TTS
Push down with a spoon against the tongue
Sour bolus (lemon)
Larger bolus volume
Cold bolus—sorbet
Chewing
Postural techniques:
Chin tuck
Head back
Head rotated to damaged side
Head rotated
Head tilt to stronger side
Swallowing techniques:
Supraglottic swallow
Super-supraglottic swallow
Effortful swallow
Mendelsohn maneuver
Recommended treatment: Diet modification:

Table 3 Protocol for therapeutic videoradiographic swallowing examination, Radiological Department, University Hospital MAS, Malmö

Consistencies		Thin liquid	Thick liquid	Carbonated	Pudding	Puree	Solid bolus
Lateral view:							
Oral preparation:	Normal	0	0	0	0	0	0
	Incomplete lip closure	1	1	1	1	1	1
	Delayed bolus preparation	2	2	2	2	2	2
	Diffuse spreading of bolus in oral cavity	2	2	2	2	2	2
Oral phase:	Normal	0	0	0	0	0	0
– Leakage	Anterior:	1	1	1	1	1	1
		2	2	2	2	2	2
	Posterior:	1	1	1	1	1	1
		2	2	2	2	2	2
– Tongue movements	Normal coordination	0	0	0	0	0	0
	Inefficient	1	1	1	1	1	1
– Mastication	Normal	0	0	0	0	0	0
	Inefficient	1	1	1	1	1	1
– Delayed bolus transport	Mild	1	1	1	1	1	1
	Moderate	2	2	2	2	2	2
Regurgitation into nasal cavity		1	1	1	1	1	1
Dissociation	<0.5 s	0	0	0	0	0	0
	0.5–2 s	1	1	1	1	1	1
	3–5 s	2	2	2	2	2	2
	>5 s	3	3	3	3	3	3
Pharyngeal phase:							
– Laryngeal elevation, Movements of os hyoid	Normal	0	0	0	0	0	0
	Reduced	1	1	1	1	1	1
	Anterior movement incomplete	2	2	2	2	2	2
	Elevation absent	3	3	3	3	3	3
– Epiglottic movement	Normal	0	0	0	0	0	0
	Incomplete	1	1	1	1	1	1
Vestibulum penetration—aspiration	No	0	0	0	0	0	0
	Subepiglottic penetration	1	1	1	1	1	1
	Supraglottic penetration	2	2	2	2	2	2
	Tracheal penetration	3	3	3	3	3	3
Constrictor muscles/ retention	No	0	0	0	0	0	0
	Weak muscles, +/− mild retention	1	1	1	1	1	1
	Paresis one segment, +/− moderate retention	2	2	2	2	2	2
	Severe paresis, +/− severe retention	3	3	3	3	3	3
PES	Normal opening	0	0	0	0	0	0
	<25% impaired	1	1	1	1	1	1
	25–50% impaired	2	2	2	2	2	2
	>50% impaired	3	3	3	3	3	3
Frontal view:							
Unilateral paresis							
Bilateral paresis							
Vocal fold closure							
Comments: Total points:							

Table 4 Disorders documented on videofluoroscopy and management (modified from Martin (1994))

Radiographic presentation	Cognitive and sensory stimulation, oral motor exercises, diet modification, alternative nutrition	Head positioning	Maneuvers
Oral phase: Anterior leakage due to incomplete lip closure Oral residue Posterior leakage due to spill over tongue base Delayed bolus preparation Diffuse spreading of bolus in oral cavity Inefficient tongue movements and mastication Delayed bolus transport Aspiration before pharyngeal swallow Regurgitation into nasal cavity	Optimise liquid/ food texture Sufficient bolus volumes Intraoral placement to unimpaired side Labial resistive exercises Buccal range of motion exercises and resistive exercises Lingual range of motion exercises and resistive exercises Bolus control exercises Thickened liquids, cold liquids, semisolids, soft solids Controlled bolus volume Thickened liquids and semisolids Bolus hold exercises	Head tilt to unimpaired side	Lip pursing Double swallow Supraglottic swallow
Dissociation: Delayed initiation of pharyngeal swallow	Thermal Tactile Stimulation. Thickened liquids. Cold stimulus. Controlled bolus volume Bolus hold exercises	Chin tuck	Supraglottic swallow
Pharyngeal phase: Laryngeal elevation reduced Movements of os hyoid: Elevation incomplete, anterior movement incomplete Epiglottis – Incomplete closure Misdirected swallows: Vestibulum laryngis – Subepiglottic penetration – Supraglottic penetration Tracheal penetration -aspiration Weakness of constrictor muscles: Mild, moderate or severe Retention Unilateral, pocketing in valleculae or/and pyriform sinus Bilateral, pocketing in valleculae or/and pyriform sinuses	Controlled bolus volume Slightly thickened liquids Thinned semi-solids Cold stimulus Thickened liquids Thermal tactile stimulation Bolus hold exercises Controlled bolus volume Liquids, semisolids and soft solids Hard swallow Controlled bolus volume Liquids and thinned semi-solids	Chin tuck Head rotation toward impaired side Head tilt toward unimpaired side Head rotation	Mendelsohn manoeuver Mendelsohn manoeuver Supraglottic swallow Supraglottic swallow Double swallow Modified supraglottic swallow Double swallow Modified supraglottic swallow
PES: – Impaired opening Regurgitation from esophagus to pyriform sinuses	Liquids, semisolids and soft solids Controlled bolus volumes		Mendelsohn maneuver Double swallow Modified supraglottic swallow
Absent pharyngeal swallow	Thermal tactile stimulation Tube feeding		

5 Protocol I: Therapeutic Videoradiographic Swallowing Examination

The protocol normally used during the TVSS examination is given in Table 2.

6 Protocol II: Therapeutic Videoradiographic Swallowing Examination

When performing research project different protocol could be used. One example is given in Table 3.

7 Swallowing Management

Upon completion of the therapeutic swallowing study, the swallowing therapist has identified the nature and severity of the swallowing disorder, makes recommendations for oral versus nonoral intake, and designs an individual treatment plan directed toward specific swallowing functional outcome goals. Every applied treatment strategy must be based on a sound rationale according to the nature of the swallowing problem and the physical and cognitive status of the patient (Table 4). In a systematic review from 2010, Speyer et al. have found that there still are many questions remaining regarding the effect of different therapeutic strategies in oropharyngeal dysphagia performed by speech–language therapists (Speyer et al. 2010). Also other studies have concluded that further research is necessary to evaluate the effectiveness of dysphagia treatment (Ashford et al. 2009; McCabe et al. 2009).

Actual research has stated that dysphagia treatment may change from using compensatory strategies to promote brain plasticity to be able to recover the swallowing function and thereby improve brain-related swallowing dysfunction (Cabib et al. 2016).

At Rose Center, University of Canterbury, New Zeeland, Professor Maggie Lee Huckabee has developed a training protocol named Biofeedback in Strength and Skill Training (BiSSkiT). This is an interesting new option for rehabilitation and outcome measurement of swallowing impairment that seems to be very promising: http://www.rose-centre.canterbury.ac.nz/bisskit/

However, often used strategies may still be used and include postural techniques, sensory improvement techniques, swallowing maneuvers, isometric exercises applied to the muscle groups of the tongue and suprahyoid musculature, and bolus volume and texture modification. Combinations of different management strategies are often used (Bülow et al. 1999; Bodén et al. 2006; Carnaby et al. 2006; Logemann 2008; Pauloski 2008).

In the managements of the dysphagic patient a team approach is often necessary and one of the most important partnerships is between speech–language pathologists and dieticians (Heiss et al. 2010). Another interdisciplinary way of management is described in a study from 2005 (Denk and Bigenzahn 2005).

A critical component in the management of dysphagic patients is providing accurate *information*. *To inform and explain current problems in an understandable way* is essential for the patient, family members, and nursing staff in terms of heightening awareness and understanding of the dysfunction, and highlighting the necessity for swallowing precautions and treatment. The successful rehabilitation of a dysphagic patient will to a large extent depend on the implementation of a team approach, with the patient and family as key components of the team.

Education of the medical and nursing staff regarding how to observe potential swallowing problems, and hosting routine patient care rounds, facilitates appropriate patient referrals and expedites the care of dysphagic patients

7.1 The Postural Techniques

To change head or body posture in dysphagic patients is for most individuals relatively easy to perform and can successfully eliminate misdirected swallows (penetration/aspiration) on liquids 75–80% of the time and is widely known and used among several speech–language pathologists (Logemann 1998; Okada et al. 2007; McCulloch

et al. 2010). *Head down (chin tuck)* widens the valleculae, pushes the tongue base backward toward the pharyngeal wall, places the epiglottis in a more posterior position, and narrows the entrance to the larynx. This position is used in cases where there is a reduction in posterior tongue base motion, unilateral laryngeal dysfunction, delayed initiation of pharyngeal swallow, and reduced laryngeal closure. For patients with weak pharyngeal constrictor muscles, a chin tuck position makes the difficulties worse, especially when swallowing a masticated bolus, which could lead to increased retention in the pharyngeal recess and post-swallow aspiration (Shanahan et al. 1993; Elmståhl et al. 1999; Welch et al. 1993; Bülow et al. 1999; Baylow et al. 2009). But chin tuck could reduce the depth of misdirected swallows (penetration/aspiration) (Bülow et al. 2001).

By using the *head back* posture, gravity can facilitate more efficient clearance of the oral cavity when oral transit is disturbed; however, good airway protection and pharyngeal swallowing mechanics must be present for safe implementation of this posture. When the *head is rotated to the damaged side* the passage through the damaged or weakened side is reduced permitting primary bolus passage through the stronger side. The *head rotation posture also pulls* the cricoid cartilage away from the posterior pharyngeal wall and facilitates passage into the cervical esophagus as in the case of decreased pharyngoesophageal segment opening (Logemann et al. 1989). *Head tilt to the stronger side results in* bolus passage down on the stronger side in *the case of* unilateral oral and pharyngeal weakness. *Lying down on one side* will take advantage of the gravity effect on pharyngeal retention, and reduce the likelihood of aspiration of residue after the swallow in cases of reduced pharyngeal contraction.

7.2 Sensory Improvement Techniques

Techniques such as thermal tactile stimulation and bolus manipulation are designed to improve oral sensory awareness and improve the timing of swallow initiation (Lazzara et al. 1986; Rosenbek et al. 1996; Lim et al. 2009; Teismann et al. 2009). Furthermore, bolus could be manipulated in different ways such as giving a sour bolus, a cold bolus, a larger volume bolus, and a bolus that requires chewing. Pressure applied to the tongue during spoon administrations of food may also facilitate productive tongue movement toward a functional swallow.

7.3 Swallowing Maneuvers

The four different techniques that are designed to change a selected aspect of the physiology of pharyngeal swallow include supraglottic swallow, super-supraglottic swallow, effortful swallow, and the Mendelsohn maneuver (Logemann 1998; Logemann and Kahrilas 1990; Kahrilas et al. 1992). Swallowing maneuvers showed during videofluoroscopy a greater range of hyoid bone displacement (van der Kruis et al. 2010). Despite their proven effectiveness in some patients, the complexity of the maneuver often precludes their usage with patient experiencing language-cognitive impairment, pulmonary disease, deconditioning, and fatigue.

7.4 Supraglottic Swallow and Super-Supraglottic Swallow

The primary purpose of these techniques is to ensure airway protection prior to and throughout the swallow.

- The techniques include instructing the patient to (1) take a breath, hold it, and, in the super-supraglottic swallow, bear down; (2) swallow; (3) clear their throat without inhaling; and (4) dry swallow. It has been shown that instructing the patient to hold their breath" hard" and" bear-down" results in optimal glottic and supraglottic closure (Martin et al. 1993; Logemann 1998).

The purpose by bearing down in the super-supraglottic swallow technique is to assist the closure of the posterior glottis and the false vocal folds.

7.5 Effortful Swallow

The purpose of this technique is to increase posterior motion of the tongue base during pharyngeal swallow. The increase in tongue base retraction associated with the maneuver should facilitate improved bolus clearance from the valleculae (Logemann 1998). This technique could also reduce the depth and severity of misdirected swallows (penetration/aspiration) (Bülow et al. 2001). In later studies effortful swallow has been studied from different perspective by using electromyography and pharyngeal manometry (Huckabee and Steele 2006; Witte et al. 2008).

Instructions

- Squeeze hard with all of your tongue muscles when you swallow.

7.6 Mendelsohn Maneuver

The purpose of this maneuver is to increase the duration and extent of laryngeal elevation and thereby increase the width and duration of (pharyngoesophageal) cricopharyngeal opening (Logemann 1998). Following early relaxation of the cricopharyngeus muscle, the pharyngoesophageal segment is pulled open as the cricoid cartilage is moved away from the posterior pharyngeal wall during upward and forward movement of the hyoid bone and larynx. The functional result of this technique is to facilitate bolus passage through the pharyngoesophageal segment and decrease the degree of pyriform residue (Lazarus et al. 1993; Wheeler-Hegland et al. 2008).

Instructions

- Pay attention to your neck by swallowing your saliva several times.
- Try to feel how your Adam's apple lifts and lowers as you swallow.
- Swallow again, and when you feel the Adam's apple lift, keep it in its highest position by squeezing the muscles of your tongue and neck for several seconds.

7.7 Oral Motor Exercises

By performing specialized exercises to the striated musculature of the tongue, pharynx, and cervical esophagus region, there is some evidence to suggest that it is possible to improve muscle strength and range of motion (Logemann 1983, 1995; Sonies 1993). The exercise program must be individually adapted depending on the specific type(s) of "swallowing impairment", and clearly documented and explained to ensure independent patient implementation whenever possible. Some exercises have prescribed intensities and frequencies, such as the Shaker exercise (Shaker et al. 1997). Other isometric strengthening exercises are usually introduced in a hierarchy of difficulty, with a gradual increase in intensity and frequency. Based on what is known about skeletal muscle physiology in other parts of the body, it is likely that the patient will need to continue an exercise maintenance program even after functional swallowing skills are acquired.

7.8 Diet Modification

Food and liquid texture modifications are in most cases found to be necessary based on the results of the therapeutic swallowing study, and to enable that the patient could maintain adequate oral nutrition. Several of our patients may suffer from language disabilities that makes it difficult to understand instructions and thereby perform different swallowing techniques. Therefore diet modifications are often the most important way to help the patient to establish a safe swallow. We have learned that sour sorbet could be very effective in the management of patients with oral swallowing dysfunction. Also carbonated liquids are a very good option for many patients, and may often be better tolerated than thickened liquids (Bülow et al. 2003; Sdravoue et al. 2011; Michou et al. 2012).

We have also found that it often may be a problem to communicate the different textures between health care professionals. The

terminology and the different textures may be very different from one health care setting to another. Wendin et al. have tried to develop a system of objective, quantitative, and well-defined food texture categories by using a combination of sensory and rheological measurements (Wendin et al. 2010).

7.9 Oral Versus Nonoral Feeding

Tube feeding methods, such as nasogastric tube, percutaneous endoscopic gastrostomy (PEG), or jejunostomy, are sometimes the only safe and efficient avenues for feeding in severely dysphagic patients. It is a common occurrence for a patient to have tube feedings as the primary source of nutrition and hydration, with safe supplementation of small amounts of modified food and liquid textures for pleasure and optimizing of quality of life. It has been found that dysphagic stroke patients who were recommended thickened-fluid dysphagia diet failed to meet their fluid requirements which was not the case in patients on enteral feeding and intravenous fluid regime (Finestone et al. 2001). Dziewas et al. analyzed however a nasogastric tube-worsened dysphagia in patients with an acute stroke. Their results showed that a correct placed nasogastric tube did not cause a worsening of stroke-related dysphagia (Dziewas et al. 2008).

In their study Logemann et al. have analyzed what information clinicians use when recommending oral versus nonoral feeding in oropharyngeal dysphagic patients (Logemann et al. 2008).

8 Therapeutic Strategies (Table 4)

Several different therapeutic strategies may be applied according to actual swallowing dysfunction. In Table 4 disorders documented on TVSS, and suggestions regarding appropriate therapeutic techniques are presented.

Conclusion

In the therapeutic swallowing study a trained speech–language pathologist and a radiologist collaborate in performing the examination.

The competence of the two specialists provides an opportunity for a complete visualization and analysis of the entire swallowing sequence. Testing swallowing function with varied bolus volumes and textures and the implementation of trial therapeutic strategies are integral components of the examination. The technique is an important tool for the SLP in the management of swallowing dysfunction.

Despite the strengths and clinical utility of the therapeutic swallowing study, there are several limitations with interpretation of test results across swallowing centers. However, new methods as the MBSS ImP allow to perform the examinations in a standardized way and thereby make the analyses of the study more efficient and the result and therapeutic intervention easier to communicate between different swallowing centers.

Evaluation of oropharyngeal swallowing function is however in its infancy. We expect that evidence-based studies will increase across centers in Europe and the United States to assist us in further determining the optimal test protocols, item analysis, and treatment strategies for improved swallowing function in our dysphagic patients, and thereby improve their quality of life.

References

Adnerhill I, Ekberg O, Groher ME (1989) Determining normal bolus size for thin liquids. Dysphagia 4:1

Arenaz Búa B, Bülow M (2014) Validation in Swedish of Sydney swallow questionnaire. BMC Res Notes 7:742

Ashford J, McCabe D, Wheeler-Hegland K, Frymark T, Mullen R, Musson N, Schooling T, Hammond CS (2009) Evidence-based systematic review: oropharyngeal dysphagia behavioral treatments: Part III—Impact of dysphagia treatments on populations with neurological disorders. J Rehabil Res Dev 46(2):195–204

Baylow HE, Goldfarb R, Taveira CH, Steinberg RS (2009) Accuracy of clinical judgment of the chin-down posture for dysphagia during the clinical/bedside assessment as

corroborated by videofluoroscopy in adults with acute stroke. Dysphagia 24(4):423–433. Epub 2009 May 30
Bingjie L, Tong Z, Xinting S, Jianmin X, Guijun J (2010) Quantitative Videofluoroscopic analysis of penetration-aspiration in post-stroke patients. Neurol India 58(1):42–47
Bodén K, Hallgren A, Witt Hedström H (2006) Effects of three swallow maneuvers analyzed by videomanometry. Acta Radiol 47(7):628–633
Bonilha HS, Humphries K, Balir J, Hill EG, McGrattan K, Carnes B, Huda W, Martin-Harris B (2013) Radiation exposure time during MBSS: influence of swallowing impairment severity, medical diagnosis, clinician experience, and standardized protocol use. Dysphagia 28(1):77–85
Bülow M, Olsson R, Ekberg O (1999) Videomanometric analysis of supraglottic swallow, effortful swallow and chin tuck in healthy volunteers. Dysphagia 14:67–72
Bülow M, Olsson R, Ekberg O (2001) Videomanometric analysis of supraglottic swallow, effortful swallow and chin tuck in patients with pharyngeal dysfunction. Dysphagia 16:190–195
Bülow M, Olsson R, Ekberg O (2003) Videoradiographic analysis of how carbonated thin thickened liquids affect the physiology of swallowing in subjects with aspiration on thin liquids. Acta Radiol 44:366–372
Cabib C, Ortega O, Kumru H, Palomeras E, Vilardell N, Alvarez-Berdugo D, Muriana D, Rofes L, Terré R, Mearin F, Clavé P (2016) Neurorehabilitation strategies for poststroke oropharyngeal dysphagia: from compensation to the recovery of swallowing function. Ann N Y Acad Sci 1380(1):121–138. doi:10.1111/nyas.13135. Epub 2016 Jul 11
Carnaby G, Hankey GJ, Pizzi J (2006) Behavioural intervention for dysphagia in acute stroke: a randomised controlled trial. Lancet neurol 5(1):31–37
De Pippo KL, Holas MA, Reding MJ (1992) Validation of the 3-ounce water swallow test for aspiration following stroke. Arch Neurol 49:1259–1261
Denk DM, Bigenzahn W (2005) Management of oropharyngeal dysphagia. Current status. HNO 53(7):661–672
Dodds WJ, Logemann JA, Stewart ET (1990a) Radiological assessment of abnormal oral and pharyngeal phases of swallow. AJR Am J Roentgenol 154:965–974
Dodds WJ, Stewart ET, Logemann J (1990b) Physiology and radiology of the normal oral and pharyngeal phases of swallowing. AJR Am J Roentgenol 154:993–963
Donner M (1988) The evaluation of dysphagia by radiography and other methods of imaging. Dysphagia 1:49–50
Dziewas R, Warnecke T, Hamacher C, Oelenberg S, Teismann I, Kraemer C, Ritter M, Ringelstein EB, Schaebitz WR (2008) Do nasogastric tubes worsen dysphagia in patients with acute stroke? BMC Neurol 23(8):28
Ekberg O (1986) Posture of the head and pharyngeal swallow. Acta Radiol Diagn 27:691–696
Ekberg O (1990) The role of radiology in evaluation and treatment of neurologically-impaired patients with dysphagia. J Neurol Rehabil 4:65–73
Ekberg O (1992) Radiologic evaluation of swallowing. In: Groher ME (ed) Dysphagia. Diagnosis and management, 2nd edn. Butterworth-Heineman, Boston, pp 163–195
Ekberg O, Bülow M, Ekman S, Hall G, Stading M, Wendin K (2009) Effect of barium sulphate contrast medium on rheology and sensory texture attributes in a model food. Acta Radiol 50(2):131–138
Elmståhl S, Bülow M, Ekberg O, Petersson M, Tegner H (1999) Treatment of dysphagia improves nutritional conditions in stroke patients. Dysphagia 14(2):61–66
Finestone HM, Foley NC, Woodbury MG, Greene-Finestone L (2001) Quantifying fluid intake in dysphagic stroke patients: a preliminary comparison of oral and nonoral strategies. Arch Phys Med Rehabil 82(12):1744–1746
Gates J, Hartnell GG, Graminga GD (2006) Videofluoroscopy and swallowing studies for neurologc disease: a primer. Radiographics 26(1):e22
Groher ME, Crary MA, Carnaby Mann G, Vickers Z, Aguilar C (2006) The impact of rheologically controlled materials on the identifications of airway compromise on the clinical and videofluoroscopic swallowing examinations. Dysphagia 21(4):218–225
Heiss CJ, Goldberg L, Dzarnoski M (2010) Registered dieticians and speech-language pathologists: an important partnership in Dysphagia management. J Am Diet Assoc 110(9):1290. 1292-1293
Huckabee ML, Steele CM (2006) An analysis of lingual contribution to submental surface electromyographic measures and pharyngeal pressure during effortful swallow. Arch Phys Med Rehabil 87(8):1067–1072
Jaffer NM, Ng E, Au FW, Steele CM (2015) Fluoroscopic evaluation of oropharyngeal dysphagia: anatomic, technical, and common etiologic factors. AJR Am J Roentgenol 204(1):49–58. doi:10.2214/AJR.13.12374
Jones B, Donner MW (1989) How I do it: examination of the patient with dysphagia. Dysphagia 4:162–172
Kahrilas PJ, Logemann JA, Gibbons P (1992) Food intake by maneuver: an extreme compensation for impaired swallowing. Dysphagia 7:155–159
Kang SH, Kim DK, Seo KM, Seo J (2011) Usefulness of videofluoroscopic swallow study with mixed consistency food for patients with stroke or other brain injuries. J Korean Med Sci 26(3):425–430. E pub 2011 Feb 25
Lazarus CL, Logemann JA, Gibbons P (1993) Effects of manoeuvres on swallowing function in a dysphagic oral cancer patient. Head Neck 15:419–424
Lazzara G, Lazarus C, Logemann J (1986) Impact of thermal stimulation on the triggering of the swallow reflex. Dysphagia 1:73–77
Lim KB, Lee HJ, Lim SS, Choi YI (2009) Neuromuscular electrical and thermal-tactile stimulation for dysphagia caused by stroke: a randomized controlled trial. J Rehabil Med 41(3):174–178
Linden P, Sibens A (1983) Dysphagia: predicting laryngeal penetration. Arch Phys Med Rehabil 64:281–283
Logemann JA (1983) Evaluation and treatment of swallowing disorders. Pro-Ed, Austin, TX

Logemann JA (1986) A manual for the videofluoroscopic evaluation of swallowing. College-Hill Press, Boston
Logemann JA (1995) Dysphagia: evaluation and treatment. Folia Phoniatr Logop 47(3):140–164
Logemann J (1998) Evaluation and treatment of swallowing disorders. Pro-Ed, Austin, TX
Logemann JA (2008) Treatment of oral and pharyngeal dysphagia. Phys Med Rehabil Clin N AM 19(4):803–816, ix
Logemann JA, Kahrilas PJ (1990) Relearning to swallow postCVA: application of maneuvers and indirect biofeedback. A case study. Neurology 40:1136–1138
Logemann JA, Kahrilas PJ, Kobara M, Vakil NB (1989) The benefit of head rotation on pharyngoesophageal dysphagia. Arch Phys Med Rehabil 70:767–771
Logemann JA, Lazarus CL, Phillips Keely S, Sanches A, Rademaker AW (2000) Effectiveness of four hours of education in interpretation of radiographic studies. Dysphagia 15:180–183
Logemann JA, Rademaker A, Pauloski BR, Antinoja J, Bacon M, Bernstein M, Gaziano J, Grande B, Kelchner L, Kelly A, Klaben B, Lundy D, Newman L, Santa D, Stachowiak L (2008) What information do clinicians use in recommending oral versus non-oral feeding in oropharyngeal dysphagia patients? Dysphagia 23(4):378–384. Epub 2008 Aug 1
Martin BJW (1994) Treatment of dysphagia in adults. In: Reiff Cherney L (ed) Clinical managements of dysphagia in adults and children. Aspen Publishers, Inc., Gaithersburg, MD, pp 153–183. Chap. 6
Martin BJW, Logemann JA, Shaker R, Dodds WJ (1993) Normal laryngeal valving patterns during three breath-hold manoeuvres: a pilot investigation. Dysphagia 8:11–20
Martin-Harris B, Jones B (2008) The videofluorographic swallowing study. Phys Med Rehabil Clin N Am 19:769–785
Martin-Harris B, Logemann JA, McMahon S, Schleicher MA, Sandidge J (2000) Clinical utility of the modified barium swallow. Dysphagia 15:136–141
Martin-Harris B, Brodsky MB, Michel Y, Castell DO, Schleicher M, Sandidge J, Maxwell R, Blair J (2008) MBS measurement tool for swallow impairment – MBSImp: establishing a standard. Dysphagia 23:392–405. doi:10.1007/s00455-008-9185-9
McCabe D, Ashford J, Wheeler-Hegland K, Frymark T, Mullen R, Musson N, Hammond CS, Schooling T (2009) Evidence-based systemtic review: oropharyngeal dysphagia behavioural treatments. Part IV—Impact of dysphagia treatment on individuals'postcancer treatments. J Rehabil Res Dev 46(2):205–214
McCulloch TM, Hoffman MR, Ciucci MR (2010) High-resolution manometry of pharyngeal swallow pressure events associated with head turn and chin tuck. Ann Otol Rhinol Laryngol 119(6):369–376
Michou E, Mastan A, Ahmed S, Mistry S, Hamdy S (2012) Examining the role of carbonation and temperatureon water swallowing performance: a swallowing reaction-time study. Chem Senses 37(9):799–807
Miller S, Kühn D, Jungheim M, Ptok M (2014) How reliable are non-instrumental assessment tools for dysphagia? HNO 62(9):654–660. doi:10.1007/s00106-014-2865-x
Murray J (1999) Videofluoroscopic examination. In: Manual of dysphagia assessment in adults. Singular Publishing Group Inc., San Diego, London, pp 113–151. Chap. 3
Nathadwarawala KM, Nicklin J, Wiles CM (1992) A timed test of swallowing capacity for neurological patients. J Neurol Neurosurg Psych 55:822–825
Nathadwarawala KM, Mc Groary A, Wiles CM (1994) Swallowing in neurological outpatients. use of a timed test. Dysphagia 9:120–129
Nordin NA, Miles A, Allen J (2017) Measuring competency development in objective evaluation of videofluoroscopic swallowing studies. Dysphagia. 32(3):427–436. doi:10.1007/s00455-016-9776-9. Epub 2017 Jan 11
Okada S, Saitoh E, Palmer JB, Matsuo K, Yokoyama M, Shigeta R, Baba M (2007) What is the chin-down posture? A questionnaire survey of speech language pathologists in Japan and in the United States. Dysphagia 22(3):204–209. Epub2007 April 10
Pauloski BR (2008) rehabilitation of dysphagia following head and neck cancer. Phys Med Rehabil Clin N Am 19(4):889–928, x
Pisegna JM, Langmore SE (2016) Parameters of instrumental swallowing evaluations: describing a diagnostic dilemma. Dysphagia 31(3):462–472. doi:10.1007/s00455-016-9700-3. Epub 2016 Mar 17
Rosenbek JC, Roecker EB, Wood JL, Robbins J (1996) Thermal application reduces the duration of stage transition in dysphagia after stroke. Dysphagia 11:225–233
Sdravoue K, Walshe M, Dagdilelis L (2011) Effect of carbonated liquids on oropharyngeal swallowing measures in people with neurogenic dysphagia. Dysphagia. doi:10.1007/s00455-011-9359-8
Shaker R, Kern M, Bardan E, Taylor A, Stewart ET, Hoffamnn RG et al (1997) Augmentation of deglutitive upper esophageal sphincter opening in the elderly by exercise. Am J Physiol 272:G1518–G1522
Shanahan TK, Logemann JA, Rademaker AW, Pauloski BR, Kahrilas PJ (1993) Chin-down posture effect on aspiration in dysphagic patients. Arch Phys Med Rehabil 74:736–739
Shaw Bonilha H, Humphries K, Blair J, Hill EG, McGrattan K, Carnes B, Huda W, Martin Harris B (2013) Radiation exposure time during MBSS: influence of swallowing impairment severity, medical diagnosis, clinician experience, and standardized protocol use. Dysphagia 28(1):77–85. doi:10.1007/s00455-012-9415-z. Published online 2012 Jun 13. PMCID: PMC3477506 NIHMSID: NIHMS386358
Sonies BC (1993) Remediation challenges in treating dysphagia post head/neck cancer. A problem-oriented approach. Clin Commun Disord 3(4):21–26. fall
Speyer R, Baijens L, Heijnen M, Zwijnenberg I (2010) Effects of therapy in oropharyngeal dysphagia by

speech and language therapists: a systematic review. Dysphagia 25(1):40–65. E pub 2009 Sep 17

Splaingard ML, Hutchins B, Sulton LD, Chauhuri G (1988) Aspiration in rehabilitation patients: videofluoroscopy vs. bedside clinical assessment. Arch Phys Med Rehabil 69:637–640

Stokely SL, Molfenter SM, Steele CM (2014) Effects of barium concentration on oropharyngeal swallow timing measures. Dysphagia 29(1):78–82. doi:10.1007/s00455-013-9485-6. Epub 2013 Sep 18

Teismann IK, Steinsträter O, Warnecke T, Suntrup S, Ringelstein EB, Pantev C, Dziewas R (2009) Tactile thermal oral stimulation increases the cortical representation of swallowing. BMC Neurosci 30(10):71

Van der Kruis JG, Baijens LW, Speyer R, Zwijnenberg I (2010) Biomechanical analysis of hyoid bone displacement in videofluoroscopy: a systematic review of intervention effects. Dysphagia. Dec 17(Epub ahead of print)

Welch MV, Logemann JA, Rademaker AW, Kahrilas PJ (1993) Changes in pharyngeal dimensions effected by chin tuck. Arch Phys Med Rehabil 74:178–181

Wendin K, Ekman S, Bülow M, Ekberg O, Johansson D, Rothenberg E, Stading M (2010) Objective and quantitative definitions of modified food textures based on sensory and rheological methodology. Food Nutr Res 54:5134. doi:10.3402/fnr.v54i0.5134

Wheeler-Hegland KM, Rosenbeck JC, Sapienza CM (2008) Submental sEMG and hyoid movement during Mendelsohn maneuver, effortful swallow, and expiratory muscle strength training. J Speech Lang Hear Res 51(5):1072–1087. Epub 2008 Aug 26

Witte U, Huckabee ML, Doeltgen SH, Gumbley F, Robb M (2008) The effect of effortful swallow on pharyngeal manometric measurements during saliva and water swallowing in healthy participants. Arch Phys Med Rehabil 89(5):822–828

Zammit-Maempel I, Chapple C-L, Leslie P (2007) Radiation dose in videofluoroscopic swallow studies. Dysphagia 22(1):13–15

Zenner PM, Losinski DS, Mills RH (1995) Using cervical auscultation in the clinical dysphagia examination in long-term care. Dysphagia 10(1):27–31