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A Protocol for the Videofluorographic Swallowing Study

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Abstract. This paper presents a detailed protocol for performing the videofluorographic swallowing study (VFSS), and describes how it evolved from its antecedents. The objectives of the VFSS are both diagnostic and therapeutic. Preparing for the VFSS is described, including the equipment, food preparation, and a brief discussion of the clinical evaluation. The detailed description of the VFSS procedure covers the position of the patient, the foods presented, the views obtained, modifications of feeding and swallowing that are commonly employed, the standardized set of observations, and reporting the results. Criteria for deviating from the protocol or aborting the study are presented. The VFSS does not necessarily end when a patient aspirates. Indeed, the complete evaluation of aspiration, and the effects of maneuvers designed to reduce it, is a major purpose of the VFSS. Modifications of feeding and swallowing are tested empirically during the study. The modifications include therapeutic and compensatory techniques that may improve the safety and efficiency of swallowing. A rationale for deciding which modifications to test in a given patient is discussed. The protocol has been used successfully in more than 350 patients. It has improved the efficiency and quality of our videofluorographic examinations.

Key words: Radiology — Videofluoroscopy — Rehabilitation — Deglutition — Deglutition disorders — Aspiration.

Videofluorography has been the gold standard for evaluating patients with swallowing disorders for many years [1,2]. Many authors have tried to detect abnormalities of swallowing (particularly aspiration) with nonradiographic observations, but these methods have poor sensitivity and specificity [2–4]. Most clinicians with a serious interest in the diagnosis and treatment of dysphagia agree that videofluorography is essential for adequate care. There is, however, less agreement on the optimal techniques for videofluorographic examination of swallowing. This paper presents a protocol for the videofluorographic swallowing study (VFSS) developed by our group.

One of the first published descriptions of a protocol for swallowing studies was the modified barium swallow (MBS), also known as the "cookie swallow," described by Logemann in 1983 [1]. In this examination, patients swallowed 2 cc of radiopaque liquid, 2 cc of paste, and ¼ of a cookie coated with barium. Liquid barium was given first, then paste, and finally the cookie. Patients were instructed to swallow on command with the liquid and paste, but to swallow the cookie at their discretion. Two swallows of each substance were recorded. This structured protocol was used extensively in clinical studies, and has been described in detail elsewhere [5].

Linden and Siebens [3,6,7], working at the Good Samaritan Hospial and Johns Hopkins University, developed an individualized approach to videofluorography based on the specific deficits in a given patient. They used representative radiopaque foods similar to those the patient ordinarily ate. The dietary staff of the hospital prepared some foods with barium, and barium was added to others just before the test. The fluorographic study started with the food which, in the clinicians' judgment, would be safest for the patient to swallow. The study progressed to other categories of foods depending on the findings with each swallow; the most challenging boluses

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with the highest risk of aspiration were presented last. Compensatory maneuvers (such as modifications of feeding or positioning) were tested empirically as a basis for formulating recommendations for diet and treatment.

Robbins et al [8] modified the MBS protocol. Beyond the standard MBS protocol, they had patients swallow 30 cc of liquid barium from a cup. More patients aspirated while drinking from the cup than while taking the 2 cc boluses, showing that the modified MBS was more sensitive for detecting aspiration. Curtis [9] described a more flexible approach that varied depending on whether the need was primarily diagnostic or therapeutic, and incorporated compensatory maneuvers. Ekberg [10] recommended three swallows (of a normal swallow size or slightly larger) of high-density barium. Like Logemann, he instructed the patient to hold the bolus in the oral cavity until asked to swallow.

In our program, the individualized approach was used for about a decade before it was decided that a stereotyped sequence of observations using standardized foods was indispensable. Testing was standardized by developing a sequence of liquid and solid foods, starting with those that are easiest for most patients to swallow, and progressing to more difficult consistencies. Products that are commercially available were mixed with prescribed amounts of barium. Provision was made for assessing compensatory techniques.

Members of the swallowing rehabilitation team (see Acknowledgments) met repeatedly before reaching consensus on a protocol. A checklist was completed after each examination for a 13-month period (122 patients) to document the completion of the protocol in the standard sequence, and to ensure that standardized observations were made during the VFSS. When examiners deviated from the standard protocol, they were required to provide a written justification. Examiners were also asked to assess the utility of the protocol after each study, and the swallowing rehabilitation team met regularly to consider comments about the protocol. The outcome of this process was a definitive protocol that has been used routinely in examinations of more than 350 patients over a 30-month period. The new protocol has three main objectives: (1) to determine the circumstances of safe alimentation and hydration for each patient; (2) to identify abnormalities of swallowing amenable to indirect treatment (such as stretching or strengthening exercises); (3) and to obtain high quality imaging to evaluate the cause of the dysphagia.

Methods

Clinical Evaluation

Each patient receives a clinical evaluation (history and physical examination) before videofluorography [11]. The clinical evaluation includes medical and psychosocial data gathered by the physician and speech-language pathologist (SLP). Clinical evaluation has several important functions, but is not intended to document laryngeal penetration or aspiration [3,4]. Rather, its purposes are to assess functional components of the swallowing mechanism; to help determine the nature and the severity of the swallowing deficit; to assess the patient's ability to perform therapeutic and compensatory maneuvers (such as neck flexion or supraglottic swallow); and to determine whether a VFSS is necessary. The major indicators for a VFSS are difficulty managing secretions, wet-hoarse dysphonia, respiratory complications, and weight loss. Psychosocial factors may affect feeding and swallowing. For a nursing home resident, oral feeding with an unusual diet or close supervision of meals may be impractical [12].

Physical examination always precedes the videofluorographic examination. The swallowing mechanism is examined as a series of functional components that prepare the food for swallowing, propel the bolus from the lips to the esophagus, and protect the larynx. For example, the face is examined for weakness; the tongue is tested for bulk, tone, and active range of motion; the velum is examined for position and symmetry at rest, and during motion elicited by phonating and gagging; the neck is palpated, and the larynx is mobilized manually and elevation of the larynx is assessed during swallowing; speech is assessed for evidence of respiratory, laryngeal, velopharyngeal, lingual, or labial dysfunction. The SLP also assesses cognitive and language abilities (such as orientation, memory, attention, judgment, and language comprehension and expression) [13] and determines the patient's ability to participate in the swallowing program and the potential need for supervision during feeding [14].

Clinical evaluation includes observing the patient during eating and drinking whenever possible. Behavior associated with dysphagia may be observed, such as drooling, slow intake of food, retaining food in the mouth after swallowing, frequent throat clearing, changing voice quality, or posturing of the head or neck with swallowing. These observations also provide information about feeding behavior and appetite. The method of presentation (such as by cup or straw), position of the patient, and need for assistance are noted. The physician and SLP discuss the findings and plan the VFSS. Pertinent issues include the physical findings, diagnosis, and purpose of the VFSS. They also discuss the foods and modifications to be tested.

Table 1. Food categories

Category	Examples[a]
Thin liquids	Apple juice, soda pop, water
Thick liquids	Apricot nectar, tomato juice, milk shakes
Ultra-thick liquids	Custard, yogurt, pudding
Formable (type A) solids	Soft cookies, mashed potatoes, purees
Particulate (type B) solids	Deviled chicken, hamburger
Multitextured (type C) solids	Beef stew, spaghetti with meatballs

[a]The first item in each category is the standard test food. The category of a particular food may vary depending on its manner of preparation.

Food Preparation

Foods in each category (Table 1) are prepared. Foods are generally provided at room temperature, except by special arrangement. Liquids are rendered radiopaque by mixing 4 oz of the liquid with 2 level scoops (about 78 cc) of barium powder. A soft cookie (about 0.9 oz) is coated with a thin layer of barium paste. Deviled chicken (4.5 oz) and beef stew (7.5 oz) are each mixed with 2 level scoops of barium powder.

Table 2. Modifications of feeding and swallowing

Volume of bolus
Delivery system: spoon, cup, straw, syringe with tube, glossectomy spoon
Physical consistency of food: liquids, solids
Posture of body
Sitting in usual position of comfort
Sitting upright
Reclining
Standing
Position of head and neck
Upright (neutral position)
Neck flexion or extension
Neck rotation
Respiratory and phonatory maneuvers
Cough, clear throat, or phonate after swallowing
Supraglottic swallow
Plug or apply valve to tracheostomy cannula
Apply nose clips
Mendelssohn maneuver
Clearance maneuvers: multiple swallows, clearing liquid swallow (alternating consistencies)
Remove feeding tube

Table 3. Standard sequence for videofluorography

Lateral projection, patient sitting in usual position of comfort
Speech sample
Swallow 5 cc of thick liquid from a spoon
Drink thick liquid from a cup (1 swallow)
Swallow 5 cc of thin liquid from a spoon
Drink thin liquid from a cup (1 swallow)
Modifications and other liquids as appropriate
Masticate and swallow 1 tsp (or 1/4 cookie) formable solid food (category A)—patient seated in usual position of comfort with head in neutral position
Masticate and swallow 1 tsp particulate solid food (category B)
Modifications and other foods as appropriate
Postero-anterior (PA) projection, patient sitting upright with neck slightly extended if possible
Take thin liquid from a cup, hold it in the mouth, and then swallow
Modifications or other foods as appropriate
Additional swallows of thin liquid as needed for imaging the esophagus

Equipment

Standard videofluoroscopic apparatus is used. Video is preferable to cineradiography because the radiation dose is lower, and instant replay is possible. The equipment also includes a seating system, VHS or Super-VHS VCR, microphone, and video timer. The videocassette recorder should provide high image quality. Slow motion and "freeze-frame" playback capabilities are needed for thorough analysis of brief swallowing events. A video timer places the correct date and time (in hundredths of a second) on each videotaped image; this is critical for timing the events of swallowing. The microphone is used to document activities and observations on the audio channel of the videotape.

The positioning system should allow the patient to sit comfortably with adequate head, trunk, and limb support. Some patients may need to recline during the study. It should be possible to obtain both postero-anterior and lateral views of the pharynx. Many centers have made customized chairs or purchased special chairs for this purpose (Videotaped Esophageal Swallow Study Chairs, Inc., Milwaukee, WI).

Videofluorography

In our institution, the VFSS is performed by the attending SLP and a rehabilitation medicine physician, preferably the patient's attending physician. A radiologist is available as needed, but does not typically perform the study. The patient is seated comfortably, and eats a variety of palatable radiopaque solid and liquid foods. Swallows are imaged first in the lateral, and then in the postero-anterior view. Abnormalities of swallowing are noted, with special attention to episodes of laryngeal penetration or retention of food after swallowing. Imaging of the esophagus is included whenever possible, to exclude gross esophageal dysfunction. When significant abnormalities occur, a variety of modifications (therapeutic and compensatory techniques) are systematically introduced, to determine whether they result in improved safety and/or efficiency of swallowing (Table 2) [5,7,15,16]. The rationale for selecting modifications is summarized below in the Discussion section.

A standardized examination protocol is followed to make studies consistent and reproducible. Examiners deviate from the standard protocol sequence only when swallowing is hazardous. *Finding aspiration does not ordinarily require stopping the study.* The protocol is aborted whenever there is evidence of airway obstruction, laryngospasm, bronchospasm, aspiration of acidic material, occlusion or impaction of the foodway, total absence of laryngeal protection, paroxysmal coughing, or a tracheo-esophageal fistula with free flow of contrast into the trachea. Several other situations represent relative contraindications to continuing the study; these require individualized clinical judgment to determine whether to continue with the standard protocol sequence. Relative contraindications include a history of recurrent aspiration (glottic penetration), with or without pneumonia. A number of other findings are considered relatively benign; if these occur, the standard protocol should be continued. Such findings include laryngeal (supraglottic) penetration, well-compensated aspiration, and retention of contrast in the pharynx after swallowing.

Standard Protocol Sequence (Table 3)

Fluoroscopy of Speech in the Lateral Projection

The patient sits with head and neck in the usual position of comfort. Images of the velum and posterior pharyngeal wall are recorded while the patient speaks to demonstrate velar elevation. Attention is also directed to motions of the tongue and lips. The standard utterance is "The mom got the pamper for the baby Suzie." If the patient cannot say the standard utterance, an alternative is used. Choices include "god," "dog," "mom," "pop," or "ah."

Fluorography of Swallowing in Lateral Projection

Images of the oral cavity (especially during mastication), velum, posterior tongue, oropharynx, hypopharynx, larynx, and pharyngoesophageal (PE) segment are recorded during swallowing. The examiners state the conditions of the current swallow on the audio channel of the recording (consistency and volume of food and method of delivery). The standard sequence of food consistencies is thick liquids, thin liquids, and then solids. Each liquid is presented first from a spoon (5 cc) and then from a cup (without control of volume). With the spoon, the patient is instructed to swallow on command of the examiner. With the cup, subjects are instructed to drink normally (volume is not controlled). Modifications may then be introduced for drinking liquids. Next, each patient eats solids foods from categories A and B; category C is optional (Table 1). Fluorography is paused intermittently during intake of solids to limit radiation exposure. Modifications of eating and swallowing solid foods may be introduced before the patient is repositioned for the postero-anterior (PA) projection.

Fluorography in the PA Projection

PA fluorography is done for every patient, except those for whom it is too hazardous or who cannot be positioned appropriately. First, the patient phonates while images of the larynx are recorded to show motions of the glottis. Next, images of the pharynx are recorded while the patient swallows thick liquid. For greater anatomical detail, some patients swallow barium paste. (For patients with a large amount of retention in the pharynx after swallowing, this may be too risky.) If there are significant abnormalities, modifications may be introduced at this point.

The esophageal stage is imaged whenever possible. Exceptions are made when swallowing is too hazardous or when the patient cannot be positioned appropriately. It is usually impossible to visualize the lower esophagus with the patient sitting. The patient stands or lies recumbent for better imaging of the lower esophagus and lower esophageal sphincter.

Observations

The structure of the cervical spine, oral cavity, tongue, palate, pharynx, larynx, and cervical esophagus are carefully evaluated, and structural defects are described. Speed and amplitude of velar elevation are observed during speech production, and glottic closure is observed during phonation. The motions of the bolus and foodway structures are observed during swallowing, and a running commentary is recorded on the audio channel of the videotape. Before leaving the fluoroscopy suite, the physician and SLP review at least one swallow in slow motion. Important functions evaluated routinely during the oral preparatory stage are mastication and oral food transport of solids, bolus formation and propulsion, and ability to contain liquid in the oral cavity before swallowing. Oral stage evaluation includes assessing bolus propulsion by the tongue and the timing of swallow onset relative to position of the leading edge of the bolus. Swallow onset is delayed abnormally if it occurs more than 2 s after a liquid bolus reaches the inferior border of the mandible (below the mandibular ramus). With solids, the delay is abnormal if it exceeds 10 s [17,18]. Functions evaluated during the pharyngeal stage include velopharyngeal apposition, laryngeal displacement, epiglottic tilt, closure of the laryngeal vestibule, pharyngeal constriction, and opening of the pharyngo-esophageal segment. Retention of contrast material in the pharyngeal recesses after swallowing is noted. When contrast material enters the larynx, the examiners observe carefully to differentiate supraglottic laryngeal penetration from aspiration (glottic penetration). The amount of contrast material aspirated or retained in the pharynx after swallowing is estimated as minimal, moderate, or severe. Also noted are the time of penetration/aspiration (before, during, or after the swallow), its mechanism (such as delayed laryngeal closure), and the response of the patient (such as prompt coughing, delayed coughing, or throat clearing).

Report of the VFSS

Following the study, the physician and SLP discuss the findings and jointly formulate the assessment. A short preliminary report form is completed in the fluoroscopy suite. The SLP dictates the introductory section of the report, briefly summarizing the history and physical findings. (This may be done prior to the study.) The physician dictates the radiographic section of the report which includes a summary of what was done (i.e., radiographic projections, position of the patient, foods presented), a description of significant structural abnormalities, a summary of the observation of swallowing (describing each functional component), a diagnostic assessment, and recommendations. Recommendations include both further diagnostic evaluations and suggested treatment. The therapeutic recommendations always include a description of the best way to aliment and hydrate the patient.

Discussion

This protocol is longer and more comprehensive than those published previously. The duration of the study varies greatly, depending on the characteristics of the patient. For patients who chew and swallow normally, the VFSS requires about 2–3 min of actual fluoroscopy; for patients who chew and swallow food very slowly, the study is longer. Some patients require extensive empirical testing of therapeutic and compensatory maneuvers under fluoroscopy. The typical fluoroscopy time for our patients ranges from 4 to 10 min. We believe that this radiation exposure is unlikely to pose a serious risk [19].

Modifications of feeding and swallowing are tested empirically during the study. The modifications include therapeutic and compensatory techniques that may improve the safety and efficiency of swallowing. They are introduced systematically during a VFSS to assess their effects on the patient's swallowing, particularly the occurrence of laryngeal penetration or retention in the foodway after swallowing. These therapeutic techniques include varying the physical characteristics of the food or modifying the circumstances of feeding, including the manner of presenting the food, posture and position of the patient, and patient behavior. Modifications also include varying the physical characteristics of the food (consistency or temperature). Deciding which modifications to test in a given patient depends on clinical judgment. We will discuss the rationale for some of the most useful techniques.

Position of the neck has major effects on swallowing [5,6,16]. Extending the neck allows gravity to help propel food into the pharynx of patients with impaired oral transport. Devices may be used to introduce food directly into the pharynx, bypassing the oral cavity. These include the glossectomy spoon for soft solid foods, and a syringe for liquids [16]. Flexing the neck before swallowing may be beneficial in patients who have poor apposition of the soft palate to the tongue. In these individuals, liquids may leak from the oral cavity into the pharynx and penetrate the unprotected larynx. Flexing the neck before swallowing reduces this by altering the relationship of gravity to the oral cavity and pharynx [16]. Flexing the neck before swallowing may also reduce aspiration by enlarging the valleculae and narrowing the laryngeal vestibule [20].

Another helpful maneuver for reducing aspiration is the "supraglottic swallow" [6]. The patient inhales and holds his or her breath before putting food in the mouth. This seals the larynx. The patient then ingests the food. After swallowing, the patient exhales forcefully, clearing the larynx. This maneuver is especially useful for patients with impaired laryngeal closure, such as after supraglottic laryngectomy. The supraglottic swallow is often combined with neck flexion during swallowing.

There are several physical maneuvers that may compensate for pharyngeal retention [11,16]. The first is simply swallowing again. Drinking liquid after eating solid food may wash retained solid food from the pharyngeal recesses. For patients with velopharyngeal incompetence, it is difficult to develop high pressure in the pharynx, because the pressure can escape through the nasal cavity. Wearing nose clips may facilitate pharyngeal clearance by raising pharyngeal pressures during swallowing. In unilateral pharyngeal palsy, turning the head toward the weak side may direct the bolus toward the stronger side of the pharynx; this improves pharyngeal clearance in many patients [21].

The Mendelssohn maneuver may improve laryngeal elevation and opening of the pharyngo-esophageal sphincter. The suprahyoid muscles contract strongly but briefly during swallowing. This pulls the hyo-laryngeal complex forward and upward, opening the sphincter. Patients may be taught to contract the suprahyoid muscles voluntarily. In the Mendelssohn maneuver, the patient contracts these muscles voluntarily during swallowing, and then maintains the contraction, keeping the pharyngo-esophageal sphincter open for a longer period [22].

The physical consistency of a food can affect the patient's ability to swallow it [3,23,24]. Many dysphagic patients experience aspiration when swallowing liquids. Thin liquids (such as apple juice) have low viscosity, run freely, and do not maintain shape within the mouth. Thick liquids (such as fruit nectar) have higher viscosity. Ultra-thick liquids (such as custard) have the highest viscosity. They are classified as liquids because they flow, have a high water content, and are used to hydrate patients. Thin liquids are difficult to contain in the oral cavity before swallow, and flow easily through narrow channels (such as a partially closed larynx). For most patients, these factors make aspiration most common with thin liquids [6,16]. Thick and ultra-thick liquids are easier to contain, but are more resistant to flow through narrow channels, such as an incompletely opened pharyngo-esophageal sphincter. They also demand the greatest propulsive force, so are more difficult to swallow for patients with weakness of pharyngeal contraction. For most patients, these factors make pharyngeal retention greatest with thick and ultra-thick liquids [16].

Several criteria are used to classify solid foods, including softness, complexity of texture, and the amount of mastication they require. Category A, "formable" solids (such as soft cookies), are most malleable, and readily form a bolus. They are soft, homogeneous, and do not break into particles. "Particulate" solids (such as deviled chicken) form a bolus less easily and may break into particles within the mouth, requiring more manipulation and control of the structures within the oral cavity. Multitextured solids (such as beef stew) are highly particulate, include two or more textures, and do not readily form a bolus. Solid foods require mastication. Even chewed solid foods are generally high in viscosity and resist flowing through narrow spaces, making them the most difficult to propel through the pharyngo-esophageal sphincter, and most likely to be retained in the pharynx after swallowing [16].

We have used this protocol successfully with patients having a variety of impairments, including structural and physiological abnormalities of swallowing. It was developed, however, with a specific patient population in mind—the population that is most commonly treated by our dysphagia team. Our patients are mostly adults with neurogenic swallowing disorders, and the largest single group consists of patients with hemispheric cerebral infarction. It may not be appropriate for patients with special needs such as infants, children, or patients with severely impaired oral function.

The VFSS protocol has contributed greatly to the development of our dysphagia rehabilitation program. This structured approach has resulted in more efficient use of time, better quality of care, more consistent data collection, and improved reporting. We are currently analyzing data collected with the VFSS, and plan to report these findings in the future.

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