Physiologically Based Evaluation Worksheet for Interpretation of the Videofluorographic Swallowing Study

Kristin France
University of Redlands

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Physiologically Based Evaluation
Worksheet for Interpretation of the Videofluorographic Swallowing Study

Kristin France
Honors Research Project
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Abstract

Clinicians assessing swallowing disorders will often use instrumental evaluations to define abnormality of swallow function and safety. Most commonly, videofluoroscopic swallow studies (VFSS) are performed to identify impaired swallow function and determine possible treatment strategies. There are known data showing poor inter- and intrarater reliability when interpreting VFSS results, which may lead to inappropriate treatment recommendations. This project examines the methods used to interpret VFSS results of dysphagic patients and the reliability of these results. There is a need for an efficient and reliable standard interpretation measure of VFSS results. A physiologically based evaluation worksheet of this nature will objectively and accurately identify the functional and dysfunctional aspects of a patient’s swallow by looking at the biomechanical aspects of swallow, the pattern of problem, and compensatory and treatment strategies. The aim of this study is to recommend new interpretation methodology that can be used by professionals to make more accurate notations of VFSS results. The evaluation worksheet will be created to increase the practicality and efficiency of current interpretation protocols. With further research this methodology should be proven to increase the validity of the VFSS examination and reduce any discrepancies in interpretation of the results.

Key words: Videofluoroscopy – Interpretation – Evaluation worksheet – Interrater reliability – Dysphagia
Videofluorographic Swallowing Study: Background

Instrumental evaluations, such as endoscopy and videofluoroscopy, are used to assess swallowing difficulties. Most commonly, the speech-language pathologist (SLP) will conduct a videofluoroscopic swallowing study (VFSS) with the assistance of a radiologist. This study consists of a moving x-ray that tracks a barium-contrasted bolus of varying size and texture through the mouth, pharynx, and cervical esophagus. The patient is asked to either sit or stand depending on the stage of swallow in question. The moving x-ray is then recorded and saved in a video format, which can later be recalled by the SLP or physician for further examination. VFSSs can be performed on both adult and pediatric patients who have been referred for further assessment based on results from the clinical examination. If proper procedure is followed and results are correctly interpreted, the VFSS should identify the normality or abnormality of swallow function and safety, and determine why it functions as such.

The VFSS should pinpoint normal and abnormal swallow physiology and patterns in addition to addressing possible treatment strategies. This project will address the clinical issues regarding proven poor inter- and intrarater reliability with VFSS, which may lead to misinterpretation of the results\(^1\)\(^-\)\(^5\). Given the importance of these outcomes in the treatment decisions, an efficient and reliable standard interpretation measure of VFSS results is needed. As described in an editorial by Ott\(^6\), the continuing problem of variation in evaluation of VFSS should result in future studies focusing on “clinical and imaging techniques used, examiner expertise and their review process, terminology and criteria for swallowing observations, and planning of serial and outcome projects\(^6\).” The topics of
imaging techniques, examiner expertise, terminology, and interpretation methodology will be discussed in the current study.

As stated by the American Speech Language-Hearing Association's technical report on the SLP's role in swallowing and feeding disorders: "Speech-language pathologists should be able to interpret and apply the results of objective testing to the formulation of dysphagia treatment plans, and to determine patient capacity and safety for oral feeding. Instrumental procedures may also be used to monitor the execution of compensatory swallowing maneuvers." Therefore, it is the SLP's responsibility to properly interpret VFSS results of possible dysphagic patients. While the procedural preferences and practices for the test vary, what is more significant is the variability among results. Misinterpretation and variability among results lead to potential treatment and diagnostic issues. "Most treatment decisions, like postural habits during swallowing, food consistencies, and swallow maneuvers, are based on the videofluoroscopic findings." After determining the relevant physiological features of dysphagia, a rating scale will be created to simplify the interpretation process and thus reduce discrepancies in analysis. A definitive protocol for VFSS interpretation is necessary if there is to be less variation in results. Through a comparison of the current measures used in the field today with the evaluation worksheet created by this study, one can note a significant improvement in practicality or ease-of-use. Future studies of reliability will demonstrate a decreased chance of the recommendation of inappropriate intervention techniques and misdiagnoses.
Inter- and Intrarater Reliability

Validity of the Examination

A review of the literature has shown there are poor inter- and intrarater reliability and general disagreement among VFSS examiners\(^1\)\(^-\)\(^5\). This variation can be attributed to problems with the validity of the examination and the proficiency of the SLP. The validity of the videofluoroscopy examination can be called into question because of the discrepancies among the definitions of the physiological markers of dysphagia. Because current interpretation protocols put great focus on normal and abnormal swallow physiology, the SLPs must determine which definitions to attribute to this complex process of swallow. Problems lie in the fact that definitions of the physiology, like “slight delay” and “poor oral preparation” are not universal. If the definitions of the relevant physiological characteristics of dysphagia were more generally agreed upon, the results of VFSS might be more consistent\(^1\).

Gibson et al. evaluated the VFSS results of four SLPs revealing “good reliability between raters and also by the same rater over a period of time, for some selected variables.”\(^3\) Mild and moderate aspiration, oral and pharyngeal phase time, number of tongue elevations, and place of bolus at initiation of swallow were all variables considered to have “good” intrarater reliability at 60-80%. While Gibson claimed this range of percentages is “good,” in reality, reliability studies should aim for no less than 80%. Valleculeae pooling was the only variable that did not achieve “good” intrarater reliability at 37%. The intrarater variable findings were consistent with the good intrarater reliability variables with the exception of place of bolus at initiation, which received reasonable
interrater agreement. Both the inter- and intrarater reliabilities of a variety of variables in this article should be improved. This project will attempt to increase the poorer reliability variables, for example of valleculae pooling, by providing a standard definition of each problem.

Kuhlemeier and Yates equate high reliability coefficients for the VFSS as well. In their study, nine experienced SLPs were asked to evaluate VFSS results and grade the patients based on a variety of physiological factors. They were shown each study twice and were not allowed to use slow motion. This is typical protocol, as SLPs usually are not allowed much time to review each case in daily practice. The interrater reliability was found to be in the 70-80% range for the physiological factors such as swallow onset timing, laryngeal elevation, pharyngeal contraction, and pharyngoesophageal segment (PES) opening. These percentages demonstrate VFSS interpretation reliability should be able to be improved, however, VFSS is sufficient for routine clinical use. The individual reliability percentages will be used as a guide for which factors need to be defined in this project.

In the literature reviewed, aspiration and semi-solid bolus presentations have produced higher reliability coefficients than other physiological characteristics of dysphagia and liquid bolus presentations. According to Stoeckli et al. and Wilcox et al. even with several modifications that were intended to facilitate the interpretation process, interrater reliability remained poor. These modifications, which included the ability to watch the study as many times and as long as needed in slow motion and frame-by-frame, and interpretation and discussion within an interdisciplinary team, were initially
thought to increase the reliability of interpretation but failed to be beneficial. The question raised by Stoeckli was whether better definitions of the physiological characteristics of dysphagia could increase reliability.

**Proficiency of the SLP**

The expertise of the SLP is another contributing factor to the variation of VFSS results. It has been shown that with four hours of additional training in identification of radiographic studies, clinicians become more competent at identifying the key structures related to dysphagia\(^8\). All participants in the study showed improvement as a result of attending the training workshop, regardless of years of swallow experience, number of swallow courses and workshops taken, and number of VFSSs done per month. With only four hours of training and testing, clinicians were better able to identify head and neck anatomy and swallowing disorders as seen in videotaped examples. This increased competency in identifying key structures of swallow and their corresponding disorders improved the reliability of VFSS interpretation\(^8\).

In addition, as seen in Wooi et al.\(^9\), when educational sessions teach anatomy and physiology of swallow and identification of swallowing structures and landmarks, students are better able to interpret VFSS results. “There was statistically significant correlation between [students’] knowledge of radiographic anatomy and their ability to interpret videofluorographic examinations.\(^9\)” Five, one-hour structured sessions were shown to teach the SLP students to more accurately identify normal anatomy and physiology of swallowing, identify radiographic anatomy and land marking, and interpret and rate the
The Bethlehem Assessment Scale (BAS) was designed by Scott\(^2\) in order to evaluate dysphagia. This 4-point rating scale assesses the patient’s level of functioning by looking at swallow physiology. As detailed by Wooi et al.\(^9\), the BAS evaluates individual parameters of swallow including labial function, lingual function, jaw function, velar function, swallow reflex, hyoid elevation, pooling in valleculae, pooling in piriform sinuses, aspiration, pharyngeal wall function, and cricopharyngeal function as seen on the VFSS. In addition, the BAS has pre-established validity and reliability data. The specific swallow parameters assessed using the BAS and their corresponding reliability data will be foundational for this project. As reported earlier, the parameters of these physiological features should be better defined in order to increase reliability of VFSS interpretation. This study will define the physiological parameters evaluated in the BAS.

There have been various attempts to standardize the interpretation of VFSS results. Most notably, Logemann provides a four-page checklist of radiographic symptoms and possible associated swallowing disorders in her *Manual for the Videofluorographic Study of Swallowing*\(^10\). This interpretation measure includes the normal and abnormal anatomy and physiology of all phases of swallow, in both lateral and A-P views, of 1mL, 3mL, 5mL, and 10mL volumes of liquid and solid boluses. The problem with this protocol, however, is its impracticality: the likelihood that an SLP will have the time to be this thorough when completing a VFSS procedure is unlikely due to difficulties associated with the demands of the procedure such as concurrently administering the VFSS and taking
data. While the checklist created by Logemann is thorough, the evaluation worksheet proposed by this study targets practicality and efficiency.

Demands of the VFSS procedure arise during the administration and interpretation of the procedure. These issues may prohibit the SLP to accurately oversee the procedure and concurrently make notations of results. The SLP is required to both administer the VFSS by feeding the patient barium-contrasted boluses and be able to take data of the procedure as well. Without the aid of an assistant or student, the SLP at times will find it difficult to complete both tasks thoroughly. Additionally, in some radiology examination rooms where the VFSS is given, the television screen that shows the x-ray is located behind the SLP. This makes it difficult to see the study online, so that any notes cannot be made. Also, the study may have to be temporarily stopped so previous swallows may be reviewed, in order for an interpretation to be made. This interpretation is often used to make decisions about what bolus volume or type is needed for subsequent swallows.
Standardizing Definitions

There is inconsistency in the definition of what physiologic abnormalities of swallowing define dysphagia. In attempts to standardize these swallow parameters, the landmarks will be clearly defined. The phases of swallow (oral preparatory, oral transfer, pharyngeal, and esophageal) are interdependent; therefore, it is imperative to understand the function of all phases during a swallow evaluation. A disease or difficulty in one location or phase may effect the other phases as well. For example, many patients might localize a complaint of the “sticking” of food in the back of the throat (pharyngeal); however, upon evaluation, it is found to be an underlying problem with the esophagus (esophageal). For this reason, a comprehensive examination of a patient with a swallowing complaint should look at all phases of swallow. In addition, with a thorough understanding of the physiology of the four phases of swallow, it will be easier to identify the problematic structure as seen in VFSS.

Dysphagia

First, it is imperative to define dysphagia and its related symptoms. Dysphagia is defined as a “delay in, or misdirection of, a fluid or solid food bolus as it moves from the mouth to the stomach.” Thus, the four phases of swallow should all be monitored for swallowing difficulty. Dysphagia may present in all age groups, from newborns to elderly patients. Patients in the hospital and in nursing home care more commonly present with symptoms of dysphagia than any other setting. Also, certain disorders are known to have dysphagia as a symptom. Head/neck cancer, stroke, brain injury, and most commonly,
neurological diseases such as Parkinson’s disease and multiple sclerosis are all causes of dysphagia.

Symptoms of dysphagia range from sensory, behavioral, and motor changes of normal swallow function. A sensory symptom includes the inability to recognize or sense food. A patient in the final stages of dementia, for example, might be unable to recognize or sense food as being an edible substance. Behavioral symptoms include unexplained weight loss, loss of appetite, unexplained pneumonia, and dehydration. Patients may not recognize that weight loss or persistent pneumonias may be triggered by dysphagia. Changes in motor abilities of swallow function include difficulty in placing food in mouth, controlling the bolus, and chewing; difficulty initiating the swallow and swallow delay; drooling; nasal or oral regurgitation; food sticking; coughing before, during, or after a swallow; and coughing at the end or after a meal. Typically these patients will realize there is a deficit in their swallow function. Common complaints include the “sticking of food” and “food going down the wrong pipe.”

Dysphagia may also lead to or be associated with health issues including aspiration pneumonia, gastroesophageal reflux, and changes in eating patterns. Aspiration pneumonia is a serious problem caused by the presence of a liquid or solid in the lungs, which develops into an infection. SLPs must be aware of the prevalence of this problem specifically in the elderly and critically ill populations. Complaints of acid or gastroesophageal reflux (heartburn) also may be associated with dysphagia. Chest pain and the taste of acid are common for this complaint. Another health issue might be a change in the patient’s eating patterns. Specific food items or times of day might cause specific
concerns for the patient. For example, the patient might only complain of eating difficulty at night when eating a large dinner and watching television.

**Phases of Swallow: Anatomy & Physiology**

The process of swallowing can be divided into four phases or stages: oral preparatory stage, oral transfer stage, pharyngeal stage, and esophageal stage. The oral preparatory stage consists of the voluntarily controlled beginning events of the swallow: bolus preparation and mastication. The oral transfer stage occurs with the bolus transported posteriorly until the pharyngeal swallow is activated. After the tongue base retracts and the bolus enters the pharynx, the pharyngeal stage begins. The purposes of this stage are to protect the airway and direct the food through the pharynx to the stomach. The last stage of swallowing is the esophageal stage in which peristaltic waves carry the bolus through the esophagus to the stomach. Successful swallow can only be attained through normally functioning swallowing physiology. Therefore, proper physiological function of each of the four stages is crucial for normal swallow.

Beginning with the oral preparatory phase of swallow, there are many key structures necessary for bolus preparation and mastication. Under voluntary control, the oral preparatory phase is the most accessible to remediate in therapy. The SLP is able to manipulate the manner in which the patient prepares boluses. Lip closure, tongue control over the positioning of the bolus, and mastication are the hallmarks of this phase of swallow. Once the bolus enters the mouth, the lips must be sealed to maintain the pressure mechanics of swallow. The tongue cradles the bolus and keeps it within the oral cavity. A
solid bolus is moved laterally on the molars, compressed against the hard palate, and mixed with saliva in preparation for swallow. Mastication, or the chewing of food in preparation for swallow, is accomplished by the molars and crushing movements of the jaw. The activity of chewing activates the salivary glands, which aid in the formation and lubrication of the bolus. The facial, mandibular, tongue, and soft palate muscles must function in coordination to reduce the bolus to a manageable size. When the bolus is sufficiently reduced, it is ready to be transferred to the pharynx.

During the oral preparatory phase, problems may arise with the lips, tongue, or muscles of mastication. If the lips do not create a sufficient seal, the process of swallowing becomes more effortful. If facial muscles are weak, food may be pocketed into the lateral or anterior sulci. If mastication muscles are weak, food may not be completely chewed. If lingual muscles are weak, saliva may not adequately mix with food, boluses may be inadequately formed, and compression of bolus onto the hard palate may be difficult. Especially if loss of sensation is coupled with weak oral musculature, there is a risk of food escaping prematurely into the pharynx before the airway has had time to close.

When the bolus is ready to be transferred into the pharynx, the oral transit phase of swallow begins. In order to propel the bolus posteriorly into the oropharynx, the anterior tongue must elevate to the alveolar ridge and hard palate, the tongue base must retract posteriorly, and the velum must begin to elevate to seal off the nasopharynx. The bolus is then squeezed back toward the faucial pillars and into the oropharynx. With the help of VFSSs, the swallow onset is seen when the bolus is propelled posteriorly. Oral transit time is the time required for the bolus to move to the beginning of the pharyngeal phase. As a
note, the onset of the oral transit stage appears to be the stimulus that triggers the activity of airway closure\textsuperscript{11}.

During the oral transit phase, problems may arise with muscle weakness of the tongue resulting in delayed oral transit. Because of their connections to the hyoid bone, the strength of the extrinsic tongue muscles is critical for swallow safety. If the tongue muscles are weak and do not pull the hyoid bone superiorly and anteriorly, the larynx will not elevate and tuck under the tongue base to protect the airway. If there is loss of laryngeal elevation, PES opening will be compromised as well. If the velum is weak, the nasopharyngeal seal is at risk of causing complications to the pressure mechanics of swallow. Also, reduced or delayed oral transit time may cause coordination issues for the rest of the swallow sequence.

Particularly of interest to SLPs, imaging of the pharyngeal phase will determine if the patient is able to adequately protect the airway and direct food into the esophagus. When the bolus reaches the faucial pillars, the pharyngeal phase of swallow begins. In order to propel the bolus into the esophagus there are specific reflexive events that must occur: the velum must completely seal off the nasopharynx, respiration must cease, the tongue base must make contact with the posterior pharyngeal wall, the vocal folds must adduct, the epiglottis must invert, the bolus must travel laterally around the epiglottis into the valleculae and piriform sinuses, the larynx must elevate and tuck under the tongue base, the hyoid bone must elevate in the superior and anterior planes, and the cricopharyngeus must relax, opening up the PES\textsuperscript{12}.
During the pharyngeal phase, slowness or delay of the specific reflexive events might cause problems with airway protection. If the velum does not elevate rapidly, nasal regurgitation may result. If the hyoid bone and larynx do not elevate, the PES will not open sufficiently, causing reduced airway protection and possible aspiration risk. If the pharyngeal constrictor muscles are weak, pharyngeal transit time, or the time required for the bolus to enter the pharynx and exit into the esophagus, will be delayed or slow. If pharyngeal muscles are weak, it may result in residual bolus remaining in the valleculae or piriform sinuses. If this residue is not voluntarily cleared, it may present an aspiration risk.

Lastly, the VFSS will determine if there is proper cervical esophagus function and, if the patient is standing, screen for peristaltic action during the esophageal phase. Once the bolus passes through the PES, it reaches the level of the cervical esophagus, thus initiating the completely involuntary esophageal phase of swallow. The bolus is propelled quickly through the esophagus by a series of peristaltic waves or contractions. There is natural delay at the level of the aortic arch where the esophagus courses laterally around the heart. As it reaches the most distal portion of the esophagus, the bolus must enter the stomach through the lower esophageal sphincter (LES). In the esophageal phase, the VFSS only examines the cervical esophagus. The imaging of the LES and the distal esophagus is reserved for an esophagram.

Typically, the function of the esophageal stage is not directly examined by the SLP\textsuperscript{12}; however, problems in the other stages of swallow may occur as a result of esophageal impairment. Reduced peristalsis in the esophagus may cause delay or backflow in the other phases of swallow or slow flow in the esophageal phase. In addition, if the LES is weak, it
may lead to abnormal relaxation of the valve. If this occurs, acid may reflux, potentially causing oral, pharyngeal, or esophageal dysphagia. Acid reflux is especially dangerous for the patient at risk for aspiration who may aspirate the erosive stomach acid.

The swallowing anatomy specifically observed in VFSS is seen below:

The diagram on the left details the anatomy of the oral cavity, pharynx, and cervical esophagus as seen in the lateral plane. The radiographic still on the right identifies the most easily identified structures of the oral cavity and pharynx using VFSS in numbered order: 1-2 are the two sides of the lower rim of the mandible, 3 is the hyoid bone, 4 is the epiglottis, 5 is the entry into the airway superior to the thyroid cartilage, 6 is the arytenoids cartilages, 7 is the true vocal folds, 8 is the valleculae, and 9 is the base of the tongue superior to the valleculae. Each of the anatomical structures noted in the radiographic still can be more clearly viewed in the diagram on the left. An SLP must be proficient in not
only the identification of normal anatomical and physiological characteristics of normal swallow, but be able to accurately identify abnormal swallow physiology as well.

Swallowing physiology is more complex due to the natural variability of normal swallow. As seen in Lof et al. 14, normal subjects perform similarly in a test-retest situation; however, there is clinically significant variability in their swallows. Data have shown that normal swallow physiology varies especially in the oral and pharyngeal phases including tongue movement, mastication, bolus preparation, and initiation of pharyngeal swallow15-18. With normal subjects, timing of the oral and pharyngeal phases changes as well. For larger boluses 5 to 20mL, the oral and pharyngeal phases progressively overlap; and for boluses larger than 20mL, the phases are concurrent9. The natural variation of normal swallow makes the SLP’s job more difficult in evaluating impaired swallow. Normal physiological changes due to aging, such as reduced hyoid movement, should be considered as well. SLPs must be able to distinguish differences in swallow physiology as being “normal variation” versus impairment.
**Videofluorographic Swallowing Study: Procedure**

While videofluoroscopy is commonly used to assess dysphagia, the administration methods followed by the SLP vary. The variability of the examiner is a common problem facing the VFSS interpretation. Logemann provides in-depth procedures to follow when administering the VFSS\textsuperscript{10}, yet many SLPs do not follow the exact protocol. According to McCullough et al., clinicians vary regarding which “videofluoroscopic methods and measures should be employed to assess swallowing function.”\textsuperscript{19} Typically, these measures vary in terms of bolus material, method of bolus presentation, criteria for judging impairment, and even the purpose of administering the examination. While SLPs vary the procedures they follow during the dysphagia assessment, this only adds to the difficulty of interpreting the VFSS.

Since the McCullough et al.\textsuperscript{19} article was published in 1999, there is little additional research that attempts to standardize the VFSS procedure. In fact, there is more research that states the variability of SLPs’ dysphagia management than their attempt to standardize the procedure\textsuperscript{20-21}. The subject of both the Glassburn et al.\textsuperscript{20} and Garcia et al.\textsuperscript{21} articles is a common treatment recommendation: the thickening of thin liquids. Considering there is no standard definition of the proper viscosities of thickened liquids, there is poor agreement on treatment planning for dysphagia management. This is in conjunction with the poor agreement on VFSS procedure standardization. The fact the variability with the evaluation techniques has been unresolved verifies the need for more efficient VFSS interpretation methodology.
In an attempt to quantify swallow function, Rademaker et al.\textsuperscript{22}, proposed the use of a single number to represent oropharyngeal swallow efficiency (OPSE). The attempt to designate a single outcome variable to represent OPSE was designed as a method to interpret VFSS results. According to the study, swallow function could be quantified before intervention through VFSS and could be used to monitor progress after rehabilitation. Analysis of each test swallow first needed to determined the following measures: oral transit time (OTT), pharyngeal delay time (PDT), pharyngeal response time (PRT), pharyngeal transit time (PTT), cricopharyngeal opening duration (CPO), laryngeal closure duration (LAC), approximate percentage of bolus (residue) remaining in the oral cavity (ORES) and pharynx (PRES) after completion of first swallow, and approximate percentage of bolus aspirated before (ASPB) and during (ASPD) swallow\textsuperscript{21}. The following mathematical formula was established to define OPSE as a function of multiple component measures typically obtained from the VFSS assessment:

\[
\text{OPSE} = 100 - \frac{(\text{ORES} + \text{PRES} + \text{ASPB} + \text{ASPD})}{\text{OTT} + \text{PDT} + \text{PRT}}
\]

The formula was used to show OPSE to be a global measure to represent the degree of safety and efficiency of swallow. While OPSE is a thorough and sensitive method to assess swallow outcome, it lacks the practicality necessary for daily clinical use as a method to interpret VFSS results. The SLP will have to spend additional time calculating the values of ORES, PRES, ASPB, ASPD, OTT, PDT, and PRT in order to obtain the OPSE amount. It may be difficult and time consuming to adjust to using mathematical scores in order to interpret VFSS results in daily clinical use.
For the purposes of this project, the procedures defined in Logemann’s *Manual for the Videofluorographic Study of Swallowing* will be used in attempts to standardize the method of VFSS interpretation. As described in the *Manual*, the three aims of VFSS are to study the anatomy and physiology of the phases of swallow, identify the patient’s pattern of problem, and define compensatory strategies and treatment recommendations.\(^{10}\) Using a fluoroscopy machine, the radiologist records moving images of various test swallows as prepared by the SLP. The patient is positioned in the normal eating posture as close to 90° as possible. Food items used in the test boluses include powder, liquid, or pudding barium, pureed food, like applesauce, finely chopped semi-solid, like diced fruit, and solids, like graham crackers. Disposable plastic spoons, cups, and syringes should be gathered for the test as well. In preparation of the boluses, “the viscosities should be consistent from one study to the next.”\(^{10}\) In addition to viscosities, bolus volumes should be consistent as well. The SLP should accurately measure the appropriate bolus sizes (1, 3, 5, 10mL) before each trial swallow. It is, most practices however, the SLP’s discretion to establish the viscosities, volumes, planes (A-P or lateral), and order of presentation that are appropriate for each patient.

Considering one of the purposes of the VFSS is to identify compensatory strategies that will facilitate swallow safety and function, an assortment of variations can be tested during the evaluation. Postural variation, increasing sensory input, and voluntary maneuvers can be attempted during the procedure in order to identify their ability to compensate. Postural variation, including chin up/down, head turn/tilt, and side lying, can be utilized to aid in bolus movement and reduction of aspiration, however they are purely...
compensatory and are not long-term changes to swallow physiology. Increased sensory input is appropriate for patients with slow oral transit and reduced recognition that food is present in the oral cavity. The immediate effects and changes to sensitivity for swallow are noted during VFSS and can be recommended as a treatment strategy. The functional voluntary maneuvers, either to protect the airway or improve bolus clearance, can be determined during the procedure and later recommended as treatment. Airway protection maneuvers, including the supraglottic and supersupraglottic swallow technique, may be used to reduce the risk of aspiration/penetration before and during swallow. Bolus clearance maneuvers, including effortful swallow and Mendelsohn maneuver, may be used to reduce pooling and residue in the pharynx.

It is imperative that the SLP considers additional variations for special populations and food presentation when relevant. Special circumstances may arise when testing certain populations considering their particular needs. Among these patients are spinal-cord-injured, tracheotomized, and ventilator-dependent patients; patients with cerebral palsy, apraxia, and vision impairments; infants and young children; and head-injured, mentally retarded, and developmentally delayed patients. While the modifications may be time-consuming for these cases, the results of the VFSS will accurately reflect their individual swallow physiology. Additionally, food presentation modifications may be necessary including changes in consistency, flavor, order, amount, and delivery method. These variations can be used to elicit a more accurate swallow.
Current Protocols

Current protocols used for analyzing VFSS results include checklists, worksheets, and rating scales. Included in the appendix are four examples of protocols used at VA Boston Healthcare\textsuperscript{23} [Appendix C], VitalStim Therapy\textsuperscript{24} [Appendix D], and two from Loma Linda University Medical Center (LLUMC)\textsuperscript{25-26} [Appendices E and F]. While these examples all examine the normality and abnormality of swallow function and safety, they do not address all three purposes of VFSS: study the anatomy and physiology of the phases of swallow, identify the patient’s pattern of problem, and define compensatory strategies and treatment recommendations. The included examples have been used as a guide for the evaluation worksheet created through this study.

The VA Boston Healthcare VFSS protocol\textsuperscript{23} [Appendix C] is a combined checklist and rating scale, which addresses the function of the swallow physiology in lateral and A-P views. The anatomy and physiology addressed in the protocol is thoroughly represented; some patterns of problem, including “lingual patterns altered” and “UES opening reduced”, are noted; and there are two examples of compensatory strategies, head turn and tilt. In addition, it includes the penetration/ aspiration scale and the dysphagia severity scale. The VA Boston Healthcare protocol is a systematic checklist; however, it fails to allow room for proper notation on additional patterns of problem and treatment recommendations. The assessment and plan portions of the evaluation’s SOAP note were intentionally overlooked, and will later be commented upon the SLP’s report.

The VitalStim Therapy checklist\textsuperscript{24} [Appendix D] takes a different approach at interpreting VFSS. The VitalStim Therapy company markets an electrical stimulation unit
used to retrain muscles used in swallow. Electrodes are placed to target specific muscle
groups contributing to the patient's particular type of dysphagia. The VitalStim VFSS
protocol is designed to not only assess signs, symptoms, and dysfunction (i.e. anatomy and
physiology and pattern of problem), but impaired muscle groups and possible electrode
placement as well. If a muscle group is impaired, the SLP must designate whether it is
weak, stiff, or a neurological innervation issue. Their interpretation protocol is thoroughly
designed for a certified medical professional that uses VitalStim; however, it would not be
beneficial for one who is not certified. What it fails to include are treatment
recommendations other than VitalStim.

For the purposes of this study, two protocols from LLUMC will be discussed. The
first Appendix E is a checklist that separates the results of the VFSS procedure into two
groups: oral phase and pharyngeal phase. Each phase includes an incomplete list of
physiological dysphagia characteristics, but fails to include the patterns of problem or
treatment and compensatory strategies. The checklist includes space to write the VFSS
results of various consistencies; however, they are written in an incorrect procedural order:
puree, honey thick liquid, nectar thick liquid, cookie, and thin liquid. SLPs from LLUMC
have suggested the order be changed to thin liquid, nectar thick liquid, honey thick liquid,
puree, and cookie. The second checklist Appendix F separates the VFSS procedure into
two groups as well: lateral view and A-P view. This protocol includes little detail in terms
of anatomy and physiology, and fails to include any patterns of problem or treatment and
compensatory strategies. There is a partial list of the physiological characteristics of
dysphagia

24
While the protocols from LLUMC are the least thorough of the examples, according to an SLP, B.M., she is designing a new checklist to be used at the hospital. Currently, many of the SLPs at LLUMC are accustomed to crossing out the checklist completely and writing a long narrative detailing the results and recommendations instead. This method is tedious, time-consuming, and impractical. The evaluation worksheet accompanying this project will be presented to B.M. as a possible alternative to their current protocols. The worksheet was designed keeping in mind B.M.'s and other SLPs' suggestions for a more efficient form. They suggested a “check-off” for the objective portion that is currently achieved through a long narrative. In addition to the noted presence of aspiration, penetration, or any other abnormality, they suggested a place to document why the SLP believes it has occurred, what they did to try to prevent it from happening, and what they plan to recommend for treatment and/or compensation. These suggestions have provided insight into what SLPs from LLUMC and possibly elsewhere believe to be problematic with the current protocols and what they would like to see on updated and more efficient versions.
Physiologically Based Evaluation Worksheet

The physiologically based evaluation worksheet for interpretation of VFSS [Appendix A] has been created using the information gathered at numerous observations at LLUMC, the Logemann checklist\textsuperscript{10}, the BAS\textsuperscript{9}, and the protocols from VA Boston Healthcare\textsuperscript{23}, VitalStim\textsuperscript{24}, and LLUMC\textsuperscript{25-26} as foundational guides for which type of methodology constitutes an efficient and practical protocol. In addition, the three purposes of the VFSS\textsuperscript{10} have been selected as the three columns of critically relevant data. The top section of the worksheet is designated for subjective information regarding patient name, attending physician, diagnosis, current diet, etc. The next section is designated for observations and results from the clinical evaluation including patient alertness and tolerance for VFSS, history of pneumonia, and unknown cause of aspiration.

The three purposes of VFSS are represented in three columns that form the body of the worksheet. The first column is a checklist of the anatomy and physiology associated with each of the four phases of swallow that can be viewed using VFSS. The SLP will use this column to check \checkmark if the characteristic is abnormal. For example, if the patient has reduced tongue movement, slow or delayed oral transit time, or no anterior tongue elevation, the boxes to the left of each factor will be checked \checkmark. All of the swallowing anatomy and physiology are written according to dysfunction.

The second column is consistent with the second purpose of VFSS: identification of the patient's pattern of problem. Here, the SLP will define the pattern of problem and each particular method of delivery the pattern was noted. There is space to write the pattern associated with each individual anatomical and physiological characteristic of swallow.
Also, the SLP will write the delivery method (e.g. thin liquid by straw) in which the pattern of problem occurred. Provided in Appendix B is an example evaluation worksheet with an example of a patient’s pattern of problems.

The third column involves a major component of VFSS that is typically omitted from protocols: the definition of compensatory strategies and treatment recommendations. Here, the SLP will identify any compensatory strategies that created a safe and functional swallow during VFSS. There is space to write the particular strategy that was used. For example, the SLP could write, “residue cleared by tilting head to pt’s R.” The sample evaluation worksheet provided in Appendix B provides additional examples of these strategies.

The physiologically based evaluation worksheet for interpretation of VFSS created with this project was taken to LLUMC to be applied in the field. B.M. provided constructive feedback and suggested some technical changes to aid in the practicality of the protocol. Specifically taking into consideration B.M.’s suggestions, the Logemann checklist\textsuperscript{10}, the BAS\textsuperscript{9}, and the protocols from VA Boston Healthcare\textsuperscript{23}, VitalStim\textsuperscript{24}, and LLUMC\textsuperscript{25-26}, the final completed protocol [Appendix A] is ready for use in the field.

Videofluoroscopic swallow studies remain to be a practical instrumental evaluation that defines abnormality of swallow function and safety and determine possible treatment strategies. Considering the poor inter- and intrarater reliability when interpreting VFSS results, the evaluation worksheet created by this project can be used to increase the practicality and efficiency of interpretation. Each of the three purposes of VFSS are addressed with the protocol including the study of the anatomy and physiology of the
phases of swallow, identification of the patient’s pattern of problem, and definition of compensatory strategies and treatment recommendations. In addition, the protocol addresses the four sections of a SOAP note. The next step is to test the reliability of the new protocol. In addition, the goal of future studies should be to move toward a scoring system that will identify if a patient needs therapy. A scoring system of this nature will drastically reduce the subjectivity of treatment recommendations and determination whether a patient requires therapy. For now, the accompanying evaluation worksheet can be used to increase VFSS result interpretation practicality and efficiency.
References


Physiologically Based Evaluation Worksheet for Videofluoroscopic Swallowing Study

PATIENT'S NAME: ____________________________

ATTENDING PHYSICIAN: ____________________________

DIAGNOSIS: ____________________________

RELEVANT CASE HISTORY: ____________________________

OBSERVATIONS/CLINICAL EVAL:
- [ ] Physically able to tolerate test
- [ ] Cognitive impairment
- [ ] Alert
- [ ] Combative
- [ ] No volitional cough
- [ ] Delayed swallow response (>5 sec) on bedside trials
- [ ] Wet phonation
- [ ] Cough with food
- [ ] Hx of pneumonia
- [ ] Hx of aspiration
- [ ] Unknown cause of asp
- [ ] Tracheostomy
- [ ] Hx of intubation
- [ ] Vocal fold paralysis

Physician's/Patient's complaint: ____________________________

Patient position/ posture: ____________________________

DATE OF STUDY: ____________________________

DATE OF ONSET OF DX: ____________________________

DATE OF ONSET OF DX: ____________________________

ANATOMY & PHYSIOLOGY

DELIVERY METHOD; PATTERN OF PROBLEM

(choose X = abnormal)

ORAL PREP PHASE
- [ ] Abnormal lip closure
- [ ] No bolus posterior mvmt (tongue)
- [ ] Mastication problems

ORAL TRANSIT PHASE
- [ ] Abnormal oral transit time
- [ ] No anterior tongue elevation
- [ ] No tongue base retraction
- [ ] No anterior-posterior bolus transit

PHARYNGEAL PHASE
- [ ] Abnormal pharyngeal transit time
- [ ] Slow/delayed movement
- [ ] Insufficient nasopharyngeal seal
- [ ] Respiration does NOT cease
- [ ] No tongue base to PPW contact
- [ ] Vocal folds do NOT adduct
- [ ] Epiglottis does NOT invert
- [ ] Bolus does NOT split into Val/PS
- [ ] Larynx does NOT elevate/tuck
- [ ] No hyoid sup/ant excursion
- [ ] PES does NOT open

ESOPHAGEAL PHASE
- [ ] Proximal esophageal stasis

PENETRATION/ASPIRATION
- [ ] Penetration—cough?
  - [ ] Before swallow
  - [ ] During swallow
  - [ ] After swallow

- [ ] Aspiration—cough?
  - [ ] Before swallow
  - [ ] During swallow
  - [ ] After swallow

RESIDUE—clears?
- [ ] FOM/oral cavity
- [ ] Tongue base
- [ ] Valleculea(e)
- [ ] Posterior pharyngeal wall
- [ ] Piriiform sinuses
- [ ] PES/cervical esophagus

COMPENSATION STRATS; RECOMMENDATIONS

(e.g. - thin, thick, purée, solid; by cup, straw, spoon; airway safety sufficient, residue @ PES)

(e.g. - chin up/down, head tilt/turn, Mendelsohn, effortful, supraglottic swallow)

APPENDIX A

DIET RECOMMENDATIONS
- [ ] NPO
- [ ] Remove feeding tube
- [ ] Thin boluses only
- [ ] Thick boluses only
- [ ] Dysphagia 1: purée
- [ ] Dysphagia 2: minced
- [ ] Dysphagia 3: ground
- [ ] Dysphagia 4: chopped
- [ ] Dysphagia 5: modified regular

K France; Revised 5/19/08
Physiologically Based Evaluation Worksheet for Videofluoroscopic Swallowing Study

**PATIENT'S NAME:**

**ATTENDING PHYSICIAN:**

**DIAGNOSIS:**

**DATE OF STUDY:**

**DATE OF ONSET OF DX:**

**RELEVANT CASE HISTORY:**

**OBSERVATIONS/CLINICAL EVAL:**

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**Patient's current diet:**

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**Physician's/Patient's complaint:**

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**Patient position/posture:**

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**ANATOMY & PHYSIOLOGY**

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**DELIVERY METHOD; PATTERN OF PROBLEM**

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**COMPENSATION STRATEGIES; RECOMMENDATIONS**

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**APPENDIX B**

K France; Revised 5/19/08
Speech Pathology Section (126) VA Boston Healthcare
Videofluoroscopic Evaluation Worksheet for Swallowing (VEWS)
Video Swallow/Modified Barium Swallow (MBS)

<table>
<thead>
<tr>
<th>Name:</th>
<th>Date:</th>
</tr>
</thead>
<tbody>
<tr>
<td>SS#:</td>
<td>Tape #:</td>
</tr>
<tr>
<td>Age:</td>
<td>DX:</td>
</tr>
<tr>
<td>Fluoro Time:</td>
<td>Position:</td>
</tr>
<tr>
<td>Other:</td>
<td>Image Capture:</td>
</tr>
</tbody>
</table>

**Lateral View**

| FUNCTION | LIQUID 3ml 3ml 5ml Rx: Large (cup) Thick 5ml PURÉE SOLID graham |
|----------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| A. Premature loss of bolus (posterior) (OC) | - | - | - | - | - | - |
| B. Labial closure reduced (drooling) (OC) | - | - | - | - | - | - |
| C. Lingual patterns altered (disorg/weak) (LP) | - | - | - | - | - | - |
| D. Velopharyngeal closure reduced (regurg) (VC) | - | - | - | - | - | - |
| E. Hyolaryngeal elevation reduced (no ant/sup) (HLE) | - | - | - | - | - | - |
| F. Epiglottic movement reduced (no invert) (ET) | - | - | - | - | - | - |
| G. Pharyngeal propulsion reduced (residue) (PP) | - | - | - | - | - | - |
| H. Residue: a. Posterior tongue (ORE) | - | - | - | - | - | - |
| b. Sulci/Palate (ORE) | - | - | - | - | - | - |
| c. Vallecula(e) (PRE) | - | - | - | - | - | - |
| d. Laryngeal vestibule (PRE) | - | - | - | - | - | - |
| e. Pyriform sinuses (PRE) | - | - | - | - | - | - |
| f. Post. pharyngeal wall (PRE) | - | - | - | - | - | - |

If residue: Patient clears SOME with:
- DS/dry swallow, C/cough, or L/liquid swallow

I. Penetration (Pen/Asp Scale*) (LC) -

J. Aspiration Trace or S/significant** (LC) -

Timing of aspiration
- B/before, D/during, A/after swallow

L. Pt. reaction to penetration/aspiration (cough/none)
- M. UES opening reduced (caliber) (UES)
- N. Other observations (e.g., Zenker's, osteophyte)

** Significant aspiration > more than 10% of bolus

**ANTERIOR - POSTERIOR VIEW**

<table>
<thead>
<tr>
<th>A. Asymmetries</th>
<th>ASSESSMENT: See report.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Symmetry of bolus transit/residue (equal) /</td>
<td></td>
</tr>
<tr>
<td>2. residue in valleculae location &gt;</td>
<td></td>
</tr>
<tr>
<td>3. residue in pyriform sinuses location &gt;</td>
<td></td>
</tr>
<tr>
<td>If unilateral try: a. turn head to affected side transit better? Y/N</td>
<td></td>
</tr>
<tr>
<td>b. tilt head to good side transit better? Y/N</td>
<td></td>
</tr>
<tr>
<td>B. Vocal cord function reduced (ah-ah-ah) Y/N</td>
<td></td>
</tr>
<tr>
<td>C. Other observations: (on back if needed): Y/N</td>
<td></td>
</tr>
</tbody>
</table>

KEY: (+) = present/observed
↑ = increased/improved
↓ = reduced/decreased/impaired/direction flow
( ) = absent/not observed
(L) = left
(R) = right
(V) = Vallecula
(PS) = Pyriform Sinus

* Pen/Asp Scale (Rosenbek et al., 1996): A (worst rating, range)
None... Penetration...... Aspiration
1 2 3 4 5 6 7 8

Waxman (et al., 1990): Severity rating
0 1 2 3 4 5 6
normal...mild......moderate...severe

Compiled by GD Gramigna/J Garcia, revised 2005
## Evaluation of Swallow Function

<table>
<thead>
<tr>
<th>Signs and symptoms</th>
<th>Dysfunction</th>
<th>Impaired muscle groups</th>
<th>Electrode placement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient ID:</td>
<td>Diagnosis:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Patient/Family/Staff report:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>□ Down lip closure</td>
<td>□ Down lip closure (lip seal)</td>
<td>□ Oropharyngeal &quot;sling&quot;</td>
<td>□ 1</td>
</tr>
<tr>
<td>□ Abnormal chewing</td>
<td>□ Down cheek tone</td>
<td>□ In- &amp; Extrinsic tongue</td>
<td>□ 2a</td>
</tr>
<tr>
<td>□ Down AP transit</td>
<td>□ Down chewing</td>
<td>□ Velopharyngeal muscles</td>
<td>□ 2b</td>
</tr>
<tr>
<td>□ Pocketing/Holding</td>
<td>□ Down tongue movement</td>
<td>□ Hyolaryngeal excursion muscles</td>
<td>□ 3a</td>
</tr>
<tr>
<td>□ Premature spillage</td>
<td>□ Down tongue base retraction</td>
<td>□ Laryngeal intrinsics</td>
<td>□ 3b</td>
</tr>
<tr>
<td>□ Down tongue base retraction</td>
<td>□ Down VP closure</td>
<td>□ Pharyngeal constrictors</td>
<td>□ 4a</td>
</tr>
<tr>
<td>□ Stasis/Coating</td>
<td>□ Down hyolaryngeal excursion</td>
<td>□ UES</td>
<td>□ 4b</td>
</tr>
<tr>
<td>□ Delayed swallow trigger</td>
<td>□ Down airway protection</td>
<td></td>
<td></td>
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<tr>
<td>□ Piecemeal deglutition</td>
<td>□ Down pharyngeal contraction</td>
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<tr>
<td>□ Oral/Nasal regurgitation</td>
<td>□ Down UES opening/closure</td>
<td></td>
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<tr>
<td>□ Down hyoid-thyroid approximation</td>
<td>□ Down esophageal motility</td>
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<tr>
<td>□ Down hyoid protraction</td>
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<tr>
<td>□ Down laryngeal elevation</td>
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<tr>
<td>□ Penetration</td>
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<td></td>
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<tr>
<td>□ Aspiration</td>
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<tr>
<td>□ Down pharyngeal squeeze</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>□ Vallecular pooling</td>
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<td></td>
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<tr>
<td>□ Pyriform pooling</td>
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<tr>
<td>□ Vallecular residuals</td>
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<tr>
<td>□ Pyriform residuals</td>
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<tr>
<td>□ Down UES opening</td>
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<td>□ Cricopharyngeal bar</td>
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<tr>
<td>□ Esophageo-pharyngeal reflux</td>
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<tr>
<td>□ Down LES opening</td>
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<tr>
<td>□ Esophageal stasis/dysmotility</td>
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<td>□ Gastroesophageal reflux</td>
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<tr>
<td>□ Down coordination</td>
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Notes:
**Modified Barium Swallow Study Checklist**

Patient Name: ____________________________
Date: ________________________________
Examiner: ____________________________

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<tr>
<th>Oral Phase</th>
<th>Puree</th>
<th>Honey Thick Liquid</th>
<th>Nectar Thick Liquid</th>
<th>Cookie</th>
<th>Thin Liquid</th>
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<tr>
<td>□ Labial Closure:</td>
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<tr>
<td>□ Leakage:</td>
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<td>□ Mastication:</td>
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<td>□ Bolus form/control:</td>
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<td>□ A-P transit:</td>
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<td>□ Oral pocketing:</td>
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<td>□ Oral residue:</td>
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Comments: ____________________________________________

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<tr>
<th>Pharyngeal Phase</th>
<th>Puree</th>
<th>Honey Thick Liquid</th>
<th>Nectar Thick Liquid</th>
<th>Cookie</th>
<th>Thin Liquid</th>
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<td>□ Delayed/absent reflex:</td>
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<td>□ Reduced peristalsis:</td>
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<td>□ Reduced laryngeal elev.:</td>
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<td>□ Penetration:</td>
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<td>□ Aspiration:</td>
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<td>□ Vallecular pooling:</td>
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<td>□ Vallecular residue:</td>
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<td>□ Pyriform Sinus residue:</td>
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Comments: ____________________________________________

**APPENDIX E**
admitting Diagnosis / Surgery: ______________________________

Orders: ______________________________ Physician: ______________________________

Precautions: ______________________________

Past Medical History: ______________________________

SUBJECTIVE:

Swallowing Problems (as described by physicians, nursing staff, patient, etc.): ______________________________

OBJECTIVE:

Previous Level of Function: ______________________________ Current Diet: ______________________________

Previous Video Swallow Evaluation Findings: ______________________________

Respiratory Status: ______________________________

Oral Motor Function: Labial: ______________________________ Lingual: ______________________________

Dentition: ______________________________ Voice: ______________________________ Speech Intelligibility: ______________________________

Other: ______________________________

(Other)

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<tr>
<th>Thin Liquid (Bolus)</th>
<th>Thick Liquid</th>
<th>Puree</th>
<th>Cracker</th>
<th>Other</th>
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<tbody>
<tr>
<td>Sm</td>
<td>Lg</td>
<td>Nectar</td>
<td>Honey</td>
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Key: SM = Small  LG = Large  ROM = Range of Motion  WFL = Within Functional Limits

Oral Prep Phase

WFL's   □ Yes   □ No

Poor / no ability to masticate material

Poor / no lip control / closure (drooling)

Other

Oral Phase

WFL’s   □ Yes   □ No

Poor tongue control (cannot form/hold bolus)

Uncontrolled bolus (early vallecular filling)

Amount of aspiration before swallow

Poor / no anterior to posterior transfer of bolus

Poor tongue control (residual in sulcus / or palate)

Pharyngeal Phase

WFL’s   □ Yes   □ No

Late / absent initiation of pharyngeal phase

Number of palatal reflex triggers before swallow

Amount of aspiration before swallow

Reduced laryngeal elevation / closure

Amount of aspiration during swallow

Reduced closure of epiglottis (% ROM)

Amount of aspiration during swallow

Reduced tongue base retraction

Amount of residue in valleculae

Amount of aspiration after swallow

Reduced pharyngeal contraction

Amount of residue in piriform sinus / posterior pharyngeal wall

Amount of aspiration after swallow

Cricopharyngeal hypertonicity

Amount of residue in piriform sinus

Amount of aspiration after swallow

Other

Signature / Title____________________________ Date / Time____________________________

LOMA LINDA UNIVERSITY MEDICAL CENTER
MODIFIED BARIUM SWALLOW EVALUATION
SPEECH-LANGUAGE PATHOLOGY
APPENDIX F