7 Evaluation of Swallow

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Introduction

The safe transport of food and liquid from the oral cavity to the esophagus involves precise coordination of both voluntary and involuntary movements involving the oropharyngeal, esophageal, laryngeal, and respiratory muscles. Dysphagia, or difficulty swallowing, can occur as a result of a broad spectrum of acute or chronic medical conditions. Dysphagia, of neurogenic origin, accounts for more than 75% of all reported cases of dysphagia, largely involving deficits in the oropharynx [1, 2]. It results in an array of medical, social, and psychological sequelae that can lead to malnutrition, dehydration, pneumonia, chronic lung disease, and decreased quality of life.

The financial consequences of neurogenic dysphagia are significant. Patel et al. explored the economic and survival burden of dysphagia among hospitalized patients. Patients with dysphagia generated costs that were $6,243 higher than those without dysphagia ($19,244 versus $13,001, $P < 0.001$). Additionally, patients in the dysphagia cohort were 33.2% more likely to be transferred to a post-acute care facility, were 1.7 times more likely to die in the hospital, and had a higher overall length of inpatient stay [3].

The trajectory of swallowing dysfunction varies depending on whether it involves an acute or progressive condition. Therefore, identification of the underlying neurological process driving dysphagia and accompanying comorbidities is critical, as it predicts the nature, urgency, and frequency of assessment. Acute onset conditions (e.g., stroke, head trauma, spinal cord injury) result in transient swallowing dysfunction. For example, dysphagia in stroke resolves in almost 90% of patients within 2 weeks [4]. Degenerative conditions (e.g., Parkinson disease, amyotrophic lateral sclerosis [ALS], Huntington disease, multiple sclerosis, and myasthenia gravis) often result in gradual, insidious, and progressive deterioration of the swallow mechanism and function.

This chapter will describe noninstrumental tools (dysphagia screening and the clinical swallow evaluation (CSE)) as well as instrumental tools (videofluoroscopic swallowing study (VFSS), flexible endoscopic evaluation of swallowing (FEES), and manometry). The intent is to describe the appropriate timing and clinical utility of each and, more importantly, how clinicians can develop a patient- and condition-centric diagnostic workflow.

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P. A. Weissbrod, D. O. Francis (eds.), *Neurologic and Neurodegenerative Diseases of the Larynx*,
https://doi.org/10.1007/978-3-030-28852-5_7

Screening

Early identification of dysphagia risk is fundamental in the setting of neurogenic disorders. In the inpatient setting, the genesis of dysphagia management is often a screening performed by nurses. The American Speech-Language-Hearing Association (ASHA) defines swallowing screening as a pass/fail procedure to identify individuals who require a comprehensive assessment of swallowing function or a referral for other professional and/or medical services [5]. While a screening provides little information about dysphagia severity or management, the objective is to differentiate patients who need a more detailed assessment with a SLP, from those who are safe for alimentation, including medications. The most robust information related to screening is found in the stroke literature. This is largely due to criteria for comprehensive stroke-ready certification which mandates facilities to have an evidenced-based, hard-wired screening tool as part of their protocol [6]. Due to inherent limitations in both labor and technological resources, screenings should be easily administered without extensive training, and be time- and cost-effective. Multiple systematic reviews have been published investigating the reliability, specificity, and sensitivity of numerous dysphagia screenings. Two tools that have strong accuracy within the neurogenic population are the Standardized Swallowing Assessment (SSA) [7] and the Toronto Bedside Swallowing Screening Test (TOR-BSST) [8–10] (Fig. 7.1).

Clinical Swallow Evaluation

The clinical swallow evaluation (CSE) is germane to the role of a SLP when managing dysphagia. A CSE does not require expensive or sophisticated technology and can be readily performed at the patient's bedside, as well as in an outpatient setting. The CSE serves to generate a detailed medical history, diagnose oral phase dysphagia, and direct clinical management. This includes diet/texture recommendations, the necessity for further testing via instrumental swallow exams to further investigate pharyngeal function, referrals to other medical specialists, and/or tailored therapeutic intervention.

The CSE begins with obtaining past and current medical history, highlighting comorbidities that affect the swallowing mechanism and function. The patient's pulmonary function, nutritional status (oral feeding versus non-oral nutrition), weight management, and history of past dysphagia assessments and/or therapies are noted. Medications are reviewed, specifically those that are known to cause dysphagia symptoms (e.g., xerostomia, tardive dyskinesia, esophageal dysmotility) [11] (Table 7.1). General observations of the patient's gait, balance, fine motor control, cognitive status, his/her ability to follow directions, and general alertness are considered.

It is crucial to have an understanding of the nature, onset, frequency, severity, and progression of the patient's dysphagia symptoms. Inquiring what types of food and liquid are easy to swallow and which are difficult, having the patient describe a typical meal, and learning how the patient takes his/her pills provide insight to the patient's current function.

Patients with neurogenic disease often present with poor perception and awareness, leaving dysphagia symptoms undetected [12]. Cognitive-communication deficits can also be a confounding factor. Recruiting family members and/or caregivers can be helpful in generating an accurate representation of the patient's swallow function.

Patient-reported outcome measures (PROM) and questionnaires assist in detecting, characterizing, and understanding symptoms. The Swallowing Disturbance Questionnaire (SDQ) was developed and validated for the detection of swallowing problems across a variety of etiologies. Cohen and Manor found that an SDQ score of more than 12.5 is a good predictor of the presence of both known and undiagnosed swallowing disturbances [13]. The EAT-10 is a second self-administered, symptom-specific PROM that can be completed in less than 2 minutes to document and monitor dysphagia severity. The normative data suggest that an EAT-10 score of three or more is abnormal [14].

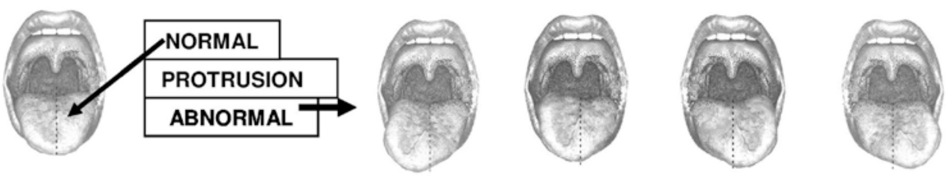
Some Guidelines and Tips for the TOR-BSST©

Before the start of screening, remember to: a) have a cup of water and a teaspoon; b) ensure patient's mouth is clean; and c) ensure patient is sitting upright at 90°.

A. Before water intake:

1. ***"I want you to say "ah" for 5 seconds using your speaking voice."***
   - Model a clear "ah" for the patient.
   - Remind them not to sing "ah" or use a quiet voice.
   - You can ask them to stretch the last syllable of the word *Ottawa*.
   - Remember to take note of the patient's voice when speaking. If his/her voice sounds different when saying "ah" re-instruct the patient to use a normal voice using any of the suggestions above.
   - **You are looking for any breathiness, gurgles, hoarseness, or whisper quality to the voice. If you perceive any of these, even to a mild degree, mark as abnormal.**

2. ***"Open your mouth. Now stick out your tongue as far as it will go. Now move it back and forth across your mouth."***
   - Stick your tongue straight out. If no deviation, model a consistent back and forth motion for the patient.
   - **You are looking for any deviation of the tongue towards one side on protrusion, or any difficulty in moving the tongue to one side. Mark as abnormal if you perceive any of these features.**
   - **If the patient is unable to protrude his/her tongue at all, mark as abnormal.**



B. Water Swallows:

Give the patient 10 X 1 tsp of water. Remind the patient to say "ah" after every teaspoon swallow. If normal, give cup to patient for drinking.

- The patient should always be fed the teaspoon of water.
- Ensure that full teaspoon amounts are given.
- Lightly palpate the throat to monitor for movement of the larynx on the first few swallows.
- **You are looking for any coughing, drooling or change in the patient's voice suggesting wetness, hoarseness, etc. If you perceive this, mark accordingly and stop the water swallows.**
- **If you see what looks like a stifled or suppressed cough, mark this as a cough.**
- **If there is no coughing, drooling, wet voice or hoarseness mark as normal.**

C. Voice after Water Swallows:

- Wait one minute after the end of the water swallows.(You can use this time to clear away the cup etc. and mark the form)
- Ask the patient to say "ah" as in the first part of the screen.

D. Final Scoring:

If you have marked ***any*** of the ***items*** as ***abnormal***, score the patient as ***Failed.***

Fig. 7.1 The Toronto Bedside Swallowing Screening Test ©. (TOR-BSST Courtesy of Rosemary Martino, MA, MSc, PhD, University of Toronto/University Health Network, Toronto, Ontario, Canada)

TOR-BSST©
The Toronto Bedside Swallowing Screening Test©

(addressograph)

DATE: ________________ *(mm/dd/yyyy)* TIME: ______________________ *(hh/mm)*

A) Before water intake: (Mark either abnormal or normal for each task.)

	Abnormal	*Normal*
1. Have patient say 'ah' and judge voice quality	☐	☐
2. Ask patient to stick their tongue out and then move it from side to side.	☐	☐

B) Water intake: Have the patient **sit upright** and give water. Ask patient to **say "ah"** after each intake. Mark as abnormal if you note any of the following signs: **coughing, change in voice quality** *or* **drooling.** If abnormal, stop water intake and advance to 'D'.

1) One Tsp Swallows	***Cough during/after swallow***	***Voice change after swallow***	***Drooling during/after swallow***	***Normal***
Swallow 1	☐	☐	☐	☐
Swallow 2	☐	☐	☐	☐
Swallow 3	☐	☐	☐	☐
Swallow 4	☐	☐	☐	☐
Swallow 5	☐	☐	☐	☐
Swallow 6	☐	☐	☐	☐
Swallow 7	☐	☐	☐	☐
Swallow 8	☐	☐	☐	☐
Swallow 9	☐	☐	☐	☐
Swallow 10	☐	☐	☐	☐
2) Cup drinking	☐	☐	☐	☐

C) After water intake: (Administer at least a minute after you finish Section B.)

	Abnormal	*Normal*
1. Have patient say 'ah' again and judge voice quality.	☐	☐

D) Results: ☐ **Passed** (no abnormal signs) ☐ **Failed → Initiate referral to SLP** (1 or more abnormal signs)

TOR-BSST© Screener's Signature: ______________________________________

June 2007 version

Fig. 7.1 (continued)

Table 7.1 Drug-induced dysphagia

Mechanism	Drug/drug classification
Xerostomia (dry mouth)	Anticholinergics Antihypertensives Cardiovascular agents Diuretics Opiates Antipsychotics Antiemetics Antidepressants Muscle relaxants Antihistamines
Reduced lower esophageal sphincter pressure (promoting gastroesophageal reflux)	Theophylline Nitrates Calcium antagonists Anticholinergics Diazepam Morphine
Esophageal injury	Antibiotics Ascorbic acid ASA and NSAIDS Ferrous sulfate Prednisone Potassium chloride Quinidine Theophylline
Extrapyramidal effects (compromising muscle function in the oropharynx and esophagus)	Antipsychotics Metoclopramide Prochlorperazine

From Sokoloff and Pavlakovic [11] with permission Springer-Verlag [11]
ASA acetylsalicylic acid (aspirin), *NSAID* nonsteroidal anti-inflammatory drug

After obtaining a thorough medical history and a comprehensive understanding of the patient's current swallowing status, the CSE can be divided into two parts: collection of noninstrumental measures and trials of food and liquid by mouth (*per oral* or PO).

Noninstrumental Measures

Prior to PO trials, the examiner administers an oral mechanism exam. Key components include:

- Cranial nerve assessment
- Structural assessment of the face, jaw, lips, tongue, dentition, hard and soft palate, oropharynx, oral mucosa and hygiene
- Assessment of muscles and structures used in swallowing, including symmetry, sensation, strength, tone, range and rate of motion, and coordination of movement:
  - The Iowa Oral Performance Instrument (IOPI Medical LLC, Redmond, WA) is a standardized portable device that can be used to objectively quantify tongue and lip strength [15, 16].
  - Tongue strength is measured by asking the patient to use his/her tongue to press a standard-sized air-filled bulb against the roof of the mouth with maximum force.

    Lip strength is measured by placing the same air-filled bulb inside the cheek just lateral to the corner of the mouth. The patient squeezes the bulb against the buccal surface of the teeth by pursing the lips with maximum force. Each task generates a numerical value in kilopascals (kPa), known as peak pressure.
  - Normative data for tongue strength in healthy adults is age-adjusted, while data for lip strength is gender-specific [16].
- Observation of head-neck control, posture, oral reflexes, secretion management, and involuntary movements (e.g., fasciculations, tremor)

Noninstrumental measures also include an informal assessment of speech, voice, and respiration.

Speech

- Connected speech sample observing articulatory precision, speech patterns, rate, and overall intelligibility (e.g., dysarthria, apraxia, dysfluency)
- Diadochokinetic rate (DDK), or a measurement of the accurate repetition of sounds within a designated amount of time

Voice

- Structured tasks and conversational voice sample noting disturbances in the parameters of pitch, intensity, resonance, prosody, and intonation.
- Observation of wet versus dry voice: A wet voice may indicate reduced sensation or

awareness of secretions within the laryngeal vestibule, poor management of secretions, and/or a risk of aspiration [17].
- Cough precision and strength: The strength and quality of the cough does not necessarily indicate that the patient will present with a reflexive cough in response to aspiration, nor that the reflexive cough, if present, is productive.
- Maximum phonation time (MPT) provides insight to glottic competency but is also a test of respiration [17].

Respiration

- Observation of the patient's respiratory rate and breathing patterns (oral or nasal), his/her coordination of respiration during phonation/speech, his/her ability to comfortably hold their breath
- Presence of a tracheostomy tube, cuff status, +/− speaking valve
- Baseline pulse oximetry and observation of oxygen saturation/desaturation during the CSE

Daniels et al. identified six clinical features as being indicative of increased risk of aspiration in acute stroke patients: dysphonia, dysarthria, abnormal volitional cough, abnormal gag reflex, cough after swallow, and voice change after swallow. Results showed that the presence of at least two of the six features has clinical significance in distinguishing patients with moderate to severe dysphagia from patients with mild dysphagia/normal swallowing [18]. These data demonstrate that the above clinical observations can provide objective criteria for the need for instrumental assessment in acute stroke patients.

Per Oral or PO Trials

Trials are administered across a continuum of both texture and volume. When the severity of dysphagia is unknown, and the patient is at high risk for aspiration, ice chips are often trialed first. Additional textures include thin, nectar, and honey-thick liquids, puree, mechanical soft, mixed consistency, and solid. Liquid bolus volumes vary from 1 ml to self-regulated consecutive drinking tasks. Administration can be patient- or examiner-directed and varies from syringe, spoon, cup, and straw.

Information relating to the oral and pharyngeal phases is gleaned from PO trials. Oral phase observations include:

- Oral bolus containment (e.g., labial seal, anterior or suspected posterior spillage)
- Oral prep and transit (e.g., mastication, bolus formation, and bolus manipulation)
- Oral holding, pocketing, and/or residue

While the pharyngeal phase of swallowing cannot be visualized, inferences of pharyngeal function are made via the following observations and tools:

- Palpation – Base of tongue, hyoid, and laryngeal movement can be assessed during the swallow by lightly palpating the area spanning the submandibular area to the inferior aspect of the thyroid cartilage. This provides information regarding timing of the swallow and laryngeal mobility [17].
- Cervical auscultation – Sounds of swallowing, swallowing-related respiration, and secretions in the airway are evaluated with a stethoscope on the lateral side of the neck in the region of the larynx. Distinct differences in acoustic and vibratory signals have been found between non-aspirating swallows from healthy controls and patients with dysphagia [19]. However, there is conflicting evidence for the validity of cervical auscultation, and the reliability of cervical auscultation is insufficient when used as a standalone tool in the diagnosis of dysphagia [20].
- Clinical signs and symptoms of penetration/aspiration – Throat clearing, wet voice quality with post-swallow phonation, coughing, choking, watering eyes, shortness of breath.
- Clinical signs and symptoms of reduced pharyngeal clearance – Multiple swallows, patient report of pharyngeal stasis and request for liquid wash.

Compensatory strategies, postural techniques, and swallow maneuvers to improve the safety and/or efficiency of the swallow are referenced in Table 7.2 [17].

Table 7.2 Compensatory strategies/postural techniques/swallow maneuvers and the rationale

Disorder/problem	Compensatory strategy/ posture/maneuver	Rationale
Poor oral bolus containment with premature spillage	Preparatory set	Improves organization and management within oral phase
	Reduced bolus size	
Poor bolus formation (including dentition)	Texture modification	Optimizes bolus manipulation and transit
Inefficient oral transit (reduced posterior propulsion of bolus by tongue)	Head back	Utilizes gravity to clear oral cavity
	Texture modification	Optimizes bolus manipulation and transit
	Reduced bolus size	Improves organization and management within oral phase
Unilateral oral dysfunction	Head tilt to stronger side	Utilizes gravity to divert bolus to intact side
Nasal regurgitation	Reduced bolus size	Compensates for reduced velopharyngeal closure
	Texture modification	
Delay in triggering the pharyngeal swallow (bolus past ramus of mandible, but pharyngeal swallow not triggered)	Chin down	Widens valleculae to prevent bolus entering airway Narrows airway entrance Pushes epiglottis posteriorly
	Supraglottic swallow	Voluntary breath hold closes vocal folds before and during swallow
	Reduced bolus size	Reduces volume burden in the pharynx
	Texture modification (increasing liquid viscosity)	Reduces speed of bolus
Reduced posterior motion of tongue base (residue in valleculae)	Chin down	Pushes tongue base backward toward pharyngeal wall
	Effortful swallow	Effort increases posterior tongue base movement
	Liquid wash	Improves bolus clearance
	Multiple swallows	
Reduced pharyngeal contraction (residue throughout pharynx)	Effortful swallow	Effort increases posterior tongue base movement; improves bolus clearance
	Texture modification (decreasing viscosity)	Promotes ease of clearance
	Reduced bolus size	
	Liquid wash	Improves bolus clearance
	Multiple swallows	
Unilateral pharyngeal weakness (residue on one side of pharynx)	Head rotated to damaged side	Redirects bolus flow to intact side
	Texture modification (decreasing viscosity)	Promotes ease of clearance
	Reduced bolus size	
	Liquid wash	Improves bolus clearance
	Multiple swallows	
Unilateral laryngeal dysfunction (aspiration during swallow)	Head rotated to damaged side	Places extrinsic pressure on thyroid cartilage, increasing adduction
	Texture modification (increasing liquid viscosity)	Reduces speed of bolus; compensates for reduced airway protection and sensation
	Chin down	Places epiglottis in more posterior protective position
	Reduced bolus size	Compensates for reduced airway protection

(continued)

Table 7.2 (continued)

Disorder/problem	Compensatory strategy/ posture/maneuver	Rationale
Reduced or late laryngeal closure (aspiration during swallow)	Chin down	Places epiglottis in more posterior protective position; narrows laryngeal entrance
	Supraglottic swallow	Voluntary breath hold usually closes vocal folds before and during swallow
	Super-supraglottic swallow	Effortful breath hold tilts arytenoids forward, closing airway entrance before and during swallow
	Texture modification (increasing liquid viscosity)	Reduces speed of bolus Compensates for reduced airway protection and sensation
	Reduced bolus size	Compensates for reduced airway protection
Reduced anterior and superior laryngeal mobility	Mendelsohn maneuver	Laryngeal movement opens the upper esophageal sphincter (UES) Prolonging laryngeal elevation, increasing duration of UES opening
Cricopharyngeal dysfunction (residue in pyriform sinuses)	Head rotation	Pulls cricoid cartilage away from posterior pharyngeal wall, reducing resting pressure in cricopharyngeal sphincter
	Mendelsohn maneuver	Laryngeal movement opens the upper esophageal sphincter (UES) Prolonging laryngeal elevation, increasing duration of UES opening
	Texture modification (decreasing viscosity)	Improves bolus clearance
	Reduced bolus size	
	Liquid wash	
	Multiple swallows	

Adapted from Logemann [17], with permission Pro-Ed

Summary of findings, recommendations regarding diet, medication administration, aspiration risk, compensatory strategies, therapy indications, and additional referrals are discussed with the patient and family. Diet texture recommendations including both liquids and solids are prescribed using the International Dysphagia Diet Standardization Initiative (https://iddsi.org/) (Fig. 7.2). This ensures consistent communication between providers and uniform preparation of food.

If the CSE suggests oropharyngeal, pharyngeal, and/or pharyngoesophageal dysphagia, or is inconclusive, instrumental assessment is warranted. See Table 7.3 for additional criteria [5]. Instrumental assessments provide measures to define the nature of dysphagia and determine the trajectory of management. A videofluoroscopic swallowing study (VFSS), also known as a modified barium swallow study (MBSS), and flexible endoscopic evaluation of swallowing (FEES) are widely accepted and utilized. VFSS and FEES each carry unique advantages, disadvantages, and clinical implications. Table 7.4 provides clinical guidance to determine the most appropriate instrumental exam. Pharyngeal manometry is an additional instrumental tool that compliments VFSS and FEES.

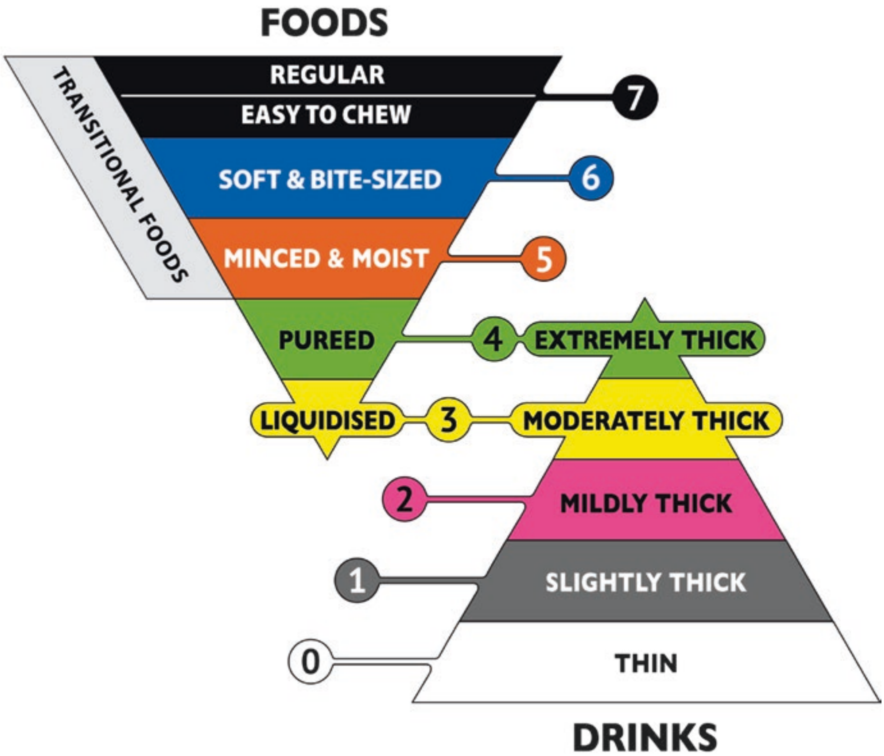


Fig. 7.2 The IDDSI framework. © The International Dysphagia Diet Standardisation Initiative 2016 @https://iddsi.org/framework/, with permission

Table 7.3 Criteria for determining whether instrumental assessment is warranted [5]

Yes	No
1. The CSE indicates signs and symptoms of dysphagia or is inconclusive	1. The CSE did not indicate dysphagia
2. Confirmation and/or differential diagnosis of dysphagia is needed	2. The patient is medically unstable and thus cannot tolerate either VFSS or FEES
3. There is a need to identify disordered swallowing physiology to guide management and treatment	3. The patient is unable to cooperate or participate in the CSE
4. Patient's nutrition, hydration, and/or pulmonary health is compromised, and there is question as to whether oropharyngeal function is contributing	4. The instrumental exam would not change management or recommendations
5. The safety and efficiency of the swallow is a concern due to a medical condition or diagnosis associated with a high risk of dysphagia	
6. The patient has previously been diagnosed with dysphagia and a change in swallow function is suspected	
7. A degenerative disease with progression is known, and oropharyngeal function may require further definition for effective management	

CSE clinical swallow examination, *VFSS* videofluoroscopic swallowing study, *FEES* flexible endoscopic evaluation of swallowing

Table 7.4 Videofluoroscopic swallowing study (VFSS) vs. flexible endoscopic evaluation of swallowing (FEES) – selecting the most appropriate instrumental exam

Clinical symptom/indication	VFSS	FEES	Either
Unknown etiology, vague symptoms, or if a comprehensive view is needed	X		
Oral phase dysphagia is suspected	X		
Question of secretion management or suspicion of aspiration of secretions		X	
Complaints of pharyngeal stasis (e.g., food sticking)			X
Esophageal complaints	X		
Extended exam needed/desired for testing of fatigue (e.g., full meal assessment)		X	
Submucosal anatomy is at question (e.g., cervical osteophytes)	X		
Visualization of surface anatomy and/or mucosal abnormalities suspected		X	
Esophagopharyngeal regurgitation	X		
Examination of movement of multiple structures at the height of the swallow (e.g., hyoid movement, laryngeal mobility)	X		
Concern regarding vocal fold mobility, dysphonia, and/or glottic closure		X	
Suspected velopharyngeal incompetence			X
Biofeedback is desired for therapeutic purposes		X	
Question of UES function (e.g., stricture, cricopharyngeal bar)	X		
Aspiration suspected during the swallow	X		
Complaints of globus sensation	X		
Sensory testing is warranted		X	
Radiation exposure issues or if the patient is pregnant		X	
History of epistaxis, vasovagal episodes, laryngospasms, and/or bilateral obstruction of the nasal passage	X		
Obesity, patients wearing a halo, cervical collar, etc., resulting in obstructed fluoroscopic views		X	
Risky transportation to radiology due to medical fragility, mechanical ventilation, transferring precautions, etc.		X	

Videofluoroscopic Swallowing Study

The videofluoroscopic swallowing study (VFSS) has been considered the gold standard for dysphagia assessment for patients demonstrating swallowing dysfunction due to various medical conditions. The technique was initially introduced by Donner and Siegel in 1965 [21]. In the 1970s, Logemann and colleagues revamped the procedure, allowing for accurate and reproducible assessment of oropharyngeal swallow function. This became the impetus for behavioral swallowing rehabilitation [17].

Technique

Fluoroscopic images are captured and recorded during dynamic swallowing. The patient can be in a seated or standing position, whichever allows for maximum comfort, optimal visualization, and safety. Radiopaque material (barium) is administered across a continuum of both texture and volume. Textures may include thin, nectar, and honey-thick liquids, puree, mechanical soft, mixed consistency, solid, and barium tablet. Volumes vary from 1 ml to self-regulated consecutive drinking tasks. Administration can be patient- or examiner-directed and varies from syringe, spoon, cup, and straw. Patients are positioned in both the lateral and anterior-posterior (AP) view in order to capture information regarding safety, efficiency, timing, and symmetry. To optimize swallowing function, stimulability probes including compensatory strategies, postural techniques, and swallow maneuvers are trialed (see Table 7.2) [17]. Dysphagia severity can be classified using the Penetration-Aspiration Scale (PAS) (Table 7.5) [22] and the Dysphagia Severity Rating Scale (Table 7.6) [23, 24].

Table 7.5 Eight-Point Penetration-Aspiration Scale (From Rosenbek et al. [22] with permission Springer-Verlag)

Score	Description
1	Material does not enter the airway
2	Material enters the airway, remains above the vocal folds, and is ejected from the airway
3	Material enters the airway, remains above the vocal folds, and is not ejected from the airway
4	Material enters the airway, contacts the vocal folds, and is ejected from the airway
5	Material enters the airway, contacts the vocal folds, and is not ejected from the airway
6	Material enters the airway, passes below the vocal folds, and is ejected into the larynx or out of the airway
7	Material enters the airway, passes below the vocal folds, and is not ejected from the trachea despite effort
8	Material enters the airway and passes below the vocal folds, and no effort is made to eject

Key members of the team include an SLP, who directs, performs, and interprets the exam; a radiology technologist, who activates and captures the fluoroscopic images; and a fluoroscopy-certified physician, who supervises the radiation dosing and also provides diagnostic interpretation. Specific roles and personnel vary by institution.

Benefits

Neurogenic dysphagia often includes both discrete and interrelated patterns of motor and/or sensory dysfunction. Table 7.7 delineates common observations within neurogenic populations [17, 25]. One defining benefit of the VFSS lies in its ability to capture not only the morphological features, but the dynamic properties of the oral, pharyngeal, and esophageal phases of swallowing. Another hallmark feature of the VFSS is the ability to visualize aspiration during the swallow in patients with diminished or absent sensory systems. Silent aspiration has been reported to present in 40–60% of patients with dysphagia of neurogenic origin [26]. Figure 7.3 is a still frame from a VFSS highlighting the presence of a cricopharyngeal bar.

Table 7.6 Dysphagia severity rating scale [23, 24]

Rating	Explanation
0	*Normal swallowing mechanism*
1	*Minimal dysphagia* – VFSS shows slight deviance from a normal swallow. Patient may report a change in sensation during swallow. No change in diet is required
2	*Mild dysphagia* – Oropharyngeal dysphagia present, which can be managed by specific swallow suggestions. Slight modification in consistency of diet may be indicated
3	*Mild-moderate dysphagia* – Potential for aspiration exists but is diminished by specific swallow techniques and a modified diet. Time for eating is significantly increased. Supplemental nutrition may be indicated
4	*Moderate dysphagia* – Significant potential for aspiration exists. Trace aspiration of one or more consistencies may be seen via VFSS. Patient may eat certain consistencies by using specific techniques to minimize potential for aspiration and/or to facilitate swallowing. Supervision at mealtimes is required. Patient may require supplemental nutrition orally or via feeding tube
5	*Moderate-severe dysphagia* – Patient aspirates 5–10% on one or more consistencies, with potential for aspiration on all consistencies. The potential for aspiration is minimized by specific swallow instructions. Cough reflex is absent or non-protective. Alternative mode of feeding is required to maintain patient's nutritional needs. If pulmonary status is compromised, "nothing by mouth" may be indicated
6	*Severe dysphagia* – Patient aspirates more than 10% of all consistencies. "Nothing by mouth" is recommended

Limitations

Inherent limitations to the VFSS are mitigated by referencing selection criteria found in Table 7.4. Two limitations warranting further discussion are radiation exposure and the subjective methods of interpretation. Due to the use of radiation, a VFSS is considered an invasive exam. This demands thoughtful and judicious utilization to keep individual and cumulative doses as low as reasonably achievable (ALARA). Due to the

Table 7.7 Videofluoroscopic swallowing study (VFSS) – common findings within neurogenic populations [17, 25]

Swallow phases	What we assess	Common findings
Oral	Lip closure Bolus preparation Bolus containment Premature spillage Oral clearance	Labial leakage (ALS, AD) Tongue dysfunction (CVA, ALS) Poor mastication (ALS, AD) Delayed bolus transit (ALS, AD) Poor bolus manipulation and control (PD) Premature spillage (PD) Oral residue (ALS, AD)
Pharyngeal	Pharyngeal swallow initiation Soft palate elevation Tongue base retraction Laryngeal excursion Anterior and superior hyoid displacement Epiglottic inversion Pharyngeal contraction Pharyngeal transit time Laryngeal closure Penetration/aspiration Pharyngeal clearance Upper esophageal opening Sensation Symmetry	Delayed swallow (PD, ALS, AD) Nasal regurgitation (ALS) Pharyngeal weakness (CVA) Prolonged pharyngeal transit time (CVA) Decreased laryngeal elevation (ALS, AD) Aspiration (CVA, ALS, AD) Silent aspiration (CVA, PD) Pharyngeal residue (PD, ALS)
Esophageal	Presence of osteophytes Presence of diverticulum Presence of narrowing/obstruction Esophageal screening Reflux	Cricopharyngeal dysfunction (PD, CVA) Poor esophageal clearance (PD) Tertiary contractions (PD) Reflux (PD)

ALS amyotrophic lateral sclerosis, *AD* Alzheimer disease, *CVA* cerebral vascular accident, *PD* Parkinson disease

Fig. 7.3 Still frame from videofluoroscopic swallowing study (VFSS) illustrating the presence of a cricopharyngeal bar

nature of neurogenic dysphagia and the need for serial exams, clinicians must perform them at critical time periods and maximize utility during each exam [27]. Careful consideration should be made, especially in the pediatric population, given the lifetime risk of radiation-association malignancy [28].

While the performance of VFSS continues to be widely used in a variety of medical settings, multiple parameters of the exam including protocol design and interpretation methods remain subjective and non-standardized. Lee et al. explored the accuracy of subjective VFSS analysis. Swallow studies were correctly classified as being normal or abnormal only 61.5% of the time. Inter- and intra-rater reliability was found to be variable, further suggesting that subjective interpretation should not stand alone [29]. To reduce dependence on subjective impressions and maximize the potential of the VFSS, Leonard and Kendall designed a novel method, now known as Swallowtail, for collecting objective surrogate measures of timing and swallowing gestures using a standardized protocol. This was not intended to replace the traditional subjective exam, but rather to apply a consistent methodology, supplying quantitative information that can be compared to normative data [30].

Flexible Endoscopic Evaluation of Swallowing

The first description of fiber-optic endoscopic evaluation of swallowing (FEES), and now more often referred to as flexible endoscopic evaluation of swallowing, was published in 1988 [31]. Susan Langmore describes the genesis of FEES as being rooted in the collaborative relationship of the otolaryngologist and SLP during traditional laryngoscopies. She recognized that the larynx, a salient region for detecting aspiration, was beautifully portrayed, thus inspiring her to use this modality to evaluate swallowing [31]. Over the last three decades, FEES has become an established instrumental exam used to evaluate the swallow mechanism and function, implement therapeutic interventions, and make recommendations for safe PO intake [32].

Technique

FEES can be performed at a patient's bedside, as well as in an outpatient setting using a flexible fiber-optic or video endoscope, which is passed transnasally. A FEES exam is comprised of three parts. The assessment begins with a survey of the structural, physiologic, and sensory mechanisms critical to swallowing function. This is accomplished by asking patients to perform non-swallow and voicing tasks. Table 7.8 provides a detailed list of these probes, as well as findings in both normal and neurogenic populations. Evaluation of secretion management is imperative in the neurogenic population and has significant predictive value for aspiration [33]. The Murray Secretion Scale (MSS) is a reliable tool to quantify accumulation of oropharyngeal secretions [34].

The second portion of the exam involves administration of food and liquid boluses. Patients ingest various consistencies, typically dyed with food coloring, with the scope in place. Textures may include: ice chips, thin, nectar, and honey-thick liquids, puree, mechanical soft, mixed consistency, and solid. Volumes vary from 1 ml to self-regulated consecutive drinking tasks. Administration can be patient, family, or clinician-directed and varies from syringe, spoon, cup, and straw. During PO trials, the examiner observes premature spillage of boluses into the pharynx or larynx, assesses airway protection and closure, and localizes residue in the pharynx and hypopharynx. To optimize swallowing function, stimulability probes including compensatory strategies, postural techniques, and swallow maneuvers are trialed (see Table 7.2). Dysphagia severity can be classified using the Penetration-Aspiration Scale (PAS) (see Table 7.5), the Dysphagia Severity Rating Scale (see Table 7.6), and the Yale Pharyngeal Residue Severity Rating Scale – an image-based, five-point ordinal rating scale quantifying residue location (vallecular and pyriform sinus) and amount (none, trace, mild, moderate, and severe) [35].

Part three is described as the intervention portion of the exam. The examiner evaluates stimulability for improved swallowing safety and efficiency. Patients are provided with modifications in postural and/or texture to optimize bolus transit and clearance and eliminate penetration and aspiration.

Both SLPs and otolaryngologists with didactic and hands-on training perform FEES. Criteria for SLPs performing the exam independently vary by state and institution.

Benefits

There are several remarkable attributes of FEES, including utilization at the patient's bedside, direct visualization of the larynx, and the ability to be used repeatedly for therapeutic purposes [32]. One illustration of these benefits is the use of endoscopic biofeedback. Biofeedback is used to learn or improve a motor skill as well as optimize patient engagement and compliance [17]. This is valuable within neurogenic dysphagia, where sensory integrity is compromised. Biofeedback expedites the accurate performance of prescribed compensatory techniques, for example, the supraglottic swallow maneuver, a head turn, or a volitional cough [31]. Manor et al. found that the use of visual assistance in the Parkinson disease pop-

Table 7.8 Non-swallow and voicing tasks prior to trials of food and liquid by mouth

Task	Indication	Normal	Neurogenic findings
"Say pa, pa, pa" "Sustain /s/"	Evaluate palatal function and closure	Full velopharyngeal closure with each syllable and sustained closure during /s/	Unilateral or bilateral velopharyngeal insufficiency
"Stick out tongue"	Visualize vallecular space	Base of tongue moves symmetrically anteriorly to allow visualization of the vallecular space	Pooling of secretions
"Say 'all', with prolonged, exaggerated vowel"	Assess base of tongue movement	Base of tongue moves symmetrically posteriorly and obstructs view of the epiglottis	Reduced or weak retraction of tongue base
"Alternate between an /i/ and a sniff"	Observe true vocal fold abduction and adduction/recurrent laryngeal nerve function	Full adduction (with phonation) and abduction (with inhalation)	Unilateral or bilateral immobility
"Glide on /i/ from high to low"	Assess superior laryngeal nerve function	True vocal folds elongate (with increased pitch) and contract (with decreased pitch); symmetric, lateral pharyngeal wall contraction at peak frequency	Truncated pitch Reduced unilateral or bilateral pharyngeal wall contraction
"Make a dolphin squeal /i/"	Evaluate pharyngeal constriction	Symmetric, lateral pharyngeal wall contraction	Reduced unilateral or bilateral pharyngeal wall contraction
"Count from 1 to 10"	Assess vocal quality and observe coordination between phonation and respiration	True vocal folds adduct for voicing resulting in glottic closure sufficient for phonation	Dysphonia; glottic incompetency; atrophy of the true vocal folds; poor respiratory support
"Hold breath tightly" (Valsalva)	Assess patient's ability to close glottis	True vocal folds adduct, false vocal folds adduct, arytenoids tilt anteriorly to base of epiglottis, completely closing off glottis	Weak or inability to demonstrate Valsalva Reduced duration of breath hold
"Puff out your cheeks like you are blowing a trumpet, but don't let the air out"	Visualize hypopharynx	Pyriform sinuses dilate bilaterally; space between arytenoids and post pharyngeal wall dilates offering visualization of the hypopharynx	Pooling of secretions Inability to perform due to nasal emission/ velopharyngeal insufficiency
"Cough"	Assess airway protection	True vocal folds symmetrically adduct abruptly; any secretions on the vocal folds and/or in the laryngeal vestibule clear	Weak, imprecise, or nonproductive cough
Laryngeal adduction reflex by lightly tapping the right and left arytenoid with the tip of the endoscope	Sensory integrity	Immediate and complete adduction of the vocal folds	Unilateral or bilateral delayed or absent response

ulation improved the understanding and implementation of strategies and enhanced patients' motivation to practice [36].

Despite the invasive nature of the exam, FEES has been found to be a safe procedure with limited incidence of adverse events. In 2016, a report of complications in 2820 FEES exams was published. Subjects included inpatients and outpatients. They reported four cases of epistaxis (0.14%), three cases of vasovagal syncope (0.1%), and two cases of laryngospasm (0.07%), three of which occurred in patients with ALS. All resolved spontaneously [37].

Fig. 7.4 Still frame from flexible endoscopic evaluation of swallowing (FEES) displaying right unilateral pharyngeal weakness

Safety of FEES was also confirmed in a series of 300 exams involving acute stroke patients. There were no reported instances of epistaxis, despite the use of anticoagulant therapy or antiplatelet drugs [38]. Figure 7.4 is a still frame from a FEES highlighting unilateral pharyngeal and laryngeal weakness with associated pooling of secretions.

Limitations

Inherent limitations to FEES are mitigated by referencing selection criteria found in Table 7.4. Three limitations that warrant further discussion are exam tolerance, limited information regarding the oral and esophageal phases, and lack of visualization of aspiration during the swallow. Poor exam tolerance can lead to a truncated exam which limits the acquisition of salient information. Patients may experience minimal discomfort, gagging, or emesis. To avoid these complications, topical analgesics are administered. When compared to VFSS, FEES offers a less holistic view with emphasis on the pharyngeal phase. In addition, events during the swallow, including aspiration, cannot be visualized during the normal white-out period when the combined effect of pharyngeal constriction and epiglottic tilt obscure the view of the larynx.

Manometry

High-resolution manometry (HRM) provides biomechanical swallowing information, which serves to inform both diagnosis and treatment strategies. The technique involves passing a flexible catheter through the nose and into the pharynx and esophagus to capture swallowing-related pressures along the catheter's sensor array [39]. The output of HRM is quantitative information including: the force of the pharyngeal propulsive wave, the squeezing tone of the UES, and the timing of the coordination between the pharyngeal contraction and UES relaxation [40].

Hoffman et al. used simultaneous HRM and videofluoroscopy to determine if results of Modified Barium Swallow Impairment Profile (MBSImP) and penetration/aspiration status could be identified from HRM alone. MBSImP parameters were correctly identified as being normal or disordered approximately 91% of the time. These data suggest HRM provides quantitative functional data at the bedside to supplement and, at times, replace traditional VFSS, thus avoiding radiation exposure [41].

HRM has potential to guide and validate the efficacy of surgical management of the UES (e.g., dilation, Botox, myotomy) and/or therapeutic interventions to optimize swallow strength and coordination. See Chap. 8 "High Resolution Manometry and Its Utility in Patients with Neurological Diseases Affecting the Larynx/Pharynx" for additional information regarding manometry.

Closing

Oropharyngeal dysphagia is a highly prevalent comorbidity in neurogenic disease and presents a serious health threat, which may lead to aspiration PNA, malnutrition, hospitalization, and death. Early identification of risk is fundamental by using a battery of diagnostic tools in a complimentary and timely fashion.

In the context of neurogenic dysphagia assessment, a patient-centric, holistic approach is paramount to maximize quality of life. Optimal outcomes are achieved by a multidisciplinary team, which may include at various stages a neurologist, registered nurse, SLP, otolaryngologist, radiologist, and dietitian.

This chapter highlights a spectrum of noninstrumental and instrumental tools, all of which play a role within dysphagia management. Assessments should be reproducible, sensitive, and specific to the condition and objective when possible. Striving to quantify swallowing disturbance is crucial in order to predict risk, accurately diagnose, and recommend effective intervention.

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