Fiberoptic Endoscopic Evaluation of Swallowing with Sensory Test (FEESST) Protocol for the Validation of a Laryngo-Pharyngeal Endoscopic Esthesiometer and Rangefinder (LPEER)

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Suggested citation for this document:


PURPOSE

This protocol is to be used during the Fiberoptic Endoscopic Evaluation of Swallowing with Sensory Test (FEESST) for the validation studies of the Laryngo-Pharyngeal Endoscopic Esthesiometer and Rangefinder (LPEER). The LPEER is a device designed to improve the reliability of the sensory evaluation of the laryngopharyngeal tract comprising an air pulse generator and an endoscopic laser rangefinder with a visual polar grid. This protocol includes the most relevant definitions, the staff participating during the test and its roles, FEESST indications and contraindications, room and equipment requirements, patient preparation, and the procedure protocol (including the anatomical and physiological examination during breathing, voice production and dry swallows, the sensory evaluation and the swallowing evaluation).

DEFINITIONS

Oropharyngeal dysphagia refers to deglutition alterations due to abnormalities in the oral or pharyngeal phases of swallowing. This may happen because of mechanical or functional alterations in any structure of the mouth, larynx, or pharynx (i.e. nasopharynx, oropharynx, or hypopharynx). Patients may also have

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1 This research project is part of the PhD program of Luis F. Giraldo-Cadavid, recipient of the grant 768-2013 from Colciencias, Colombia; the grant MED-164-2013, from the University of La Sabana (Chia, Colombia); and the support of the University of Navarra (Pamplona, Spain). L. F. Giraldo-Cadavid is a PhD student at the University of Navarra, School of Medicine, Pamplona, Navarra 31080 Spain; a Clinical Professor at the University of La Sabana School of Medicine, Chia, Cundinamarca 250001 Colombia (phone: +57 3106083557; e-mail: lgraaloro.alumni.unav.es; lfgiraldo@unisabana.edu.co); and a pulmonary doctor at Fundación Neumológica Colombiana.
dysphagia due to mechanical or functional abnormalities in the esophageal phase of swallowing, in which case we talk about esophageal dysphagia.\(^5\text{-}^{10}\)

The Fiberoptic Endoscopic Evaluation of Swallowing with Sensory Test (FEESST) is performed using a thin fiberoptic endoscope with a working channel of 1.2 mm.\(^12\) The endoscopist introduces the endoscope through the patient’s nasal cavity. It is lubricated with water-soluble gel to decrease discomfort. The endoscopist does not use anesthetics because the FEESST only produces mild to moderate discomfort, it is infrequently associated with pain, and anesthetics might alter the reflexes needed for deglutition and measurement of their thresholds.

The FEESST has two core components: the sensory evaluation and the swallowing evaluation. The sensory evaluation consists of administering pulses of air at different intensities to the patient to stimulate and determine the reflex thresholds of the laryngeal adductor (LART), cough (CRT), and gag reflexes (GRT). The swallowing evaluation assesses the efficiency and safety of deglutition while the patient eats foods of four different consistencies: solid, semi-solid, thick liquid, and thin liquid. Alterations of swallowing safety refers to aspiration of material below the vocal cords or to swallowing alterations that put the patient on imminence of aspiration. Alterations of swallowing efficiency refer to swallowing abnormalities that do not put the patient on imminence of aspiration. Detailed definitions of alterations of swallowing safety and efficiency will be provided below. When the patient has severe alterations in swallowing safety, however, it might be necessary to stop all oral feeding and select an alternate route of feeding (e.g. nasogastric tube or gastrostomy).

**STAFF AND TASKS**

The FEESST is performed by a team of professionals, consisting of a pulmonary or an otorhinolaryngology (ENT) doctor, a speech-language pathologist (SLP), and a clinical or technical assistant.\(^12\text{-}^{13}\)

First, the subjects undergo a clinical evaluation by a Speech Language Pathologist (SLP) with 7 years of experience in dysphagia using a standard form. The clinical evaluation includes the subjects’ past medical history; questions exploring swallowing safety and efficacy; a physical exam that includes anatomical and functional evaluations of the head, neck and upper-aerodigestive structures; and a validated Spanish version of the EAT-10.\(^14\)

The endoscopist explains the FEESST and its potential benefits and risks to the subject undergoing the test and his relatives. Afterwards, the endoscopist obtains the written informed consent of the subject and/or his relatives. The endoscopist performs the FEESST in collaboration with an SLP.

During the test, the SLP gives food to the patient, performs a clinical examination of the patient’s swallowing by external inspection, and looks at the video-endoscope monitor to assess the efficiency and safety of the patient’s swallowing.
A clinical assistant helps during the test aspirating patient’s secretions when necessary, filling out the FEESST report form and providing any other necessary assistance.

A technical assistant may be also present during the test to prepare the equipment and make necessary modifications to the equipment settings during the test. When a technical assistant is not present, his/her tasks are assumed by the clinical assistant.

**INCLUSION CRITERIA**

The inclusion criteria for the LPEER clinical validation studies include usual clinical indications of the FEESST, but also research indications (even in the absence of clinical indications) related to the purposes of this project:

- Age of 18 years or older.
- Obstructive Sleep Apnea-Hypopnea Syndrome
- Cough
- Symptoms of oropharyngeal dysphagia, including coughing, choking, a wet voice, throat clearance, or dysphonia during or after swallowing (4, 10, 15)
- Aspiration pneumonia, recurrent pneumonia, pulmonary infiltrates consistent with aspiration (10, 16)
- Neurological or muscular diseases involving the head or neck muscles (e.g. amyotrophic lateral sclerosis, Parkinson´s disease, multiple sclerosis, myasthenia gravis, polymyositis, myopathies, neuropathies) (13)
- Risk of oropharyngeal dysphagia (e.g. stroke, brain trauma) (13, 17, 18)
- People without dysphagia volunteering to the study to serve as controls or to look at the sensory alterations associated with other conditions.

**EXCLUSION CRITERIA**

The exclusion criteria for LPEER clinical validation studies include clinical contraindications of the FEESST, but also research contraindications aimed at keeping FEESST a minimal-risk procedure. (4, 11-13, 19-21)

- Severe respiratory failure (PaO2/FiO2 < 200)
- Bleeding diathesis
- Anticoagulation (though not a contraindication for the FEESST, anticoagulation is an exclusion criteria for this validation study in order to keep it a minimal-risk study)

**RISKS ASSOCIATED WITH THE FEESST**

The FEESST is a safe procedure. It produces moderate discomfort, but adverse events are infrequent, occurring in less than 0.2% of cases. Its complications include: *(12, 19, 21)*

- Nasal bleeding (epistaxis): less than 0.1% of procedures *(19, 21)*

- Lightheadedness (caused by vagal reflex): rare reports *(20)*

**PATIENT PREPARATION FOR THE FEESST**

Nothing by mouth (*nil per os*, or NPO) before the FEESST is not strictly required because patients who undergo the procedure receive food by mouth during the test. However, two hours of fasting may be helpful to promote appetite and facilitate reception of food during the test.

**EXAMINATION ROOM**

The FEESST does not require special patient monitoring. It can be done bedside or in a clinical office, endoscopy room, operating room, emergency room, or intensive care unit, among other places. *(4, 11, 12, 19-21)*

**EQUIPMENT**

1. Fiberoptic endoscope

2. Light source

3. Head camera for video-endoscopy

4. Image processor

5. Computer

6. Suction instrument

7. Oxygen source (for air supply to the esthesiometer. If the patient is on supplementary oxygen, an additional oxygen source would be required).

8. Oxygen tubes
9. Examination gloves

10. Sphygmomanometer and stethoscope

11. Drinking water

12. Regular, thin yogurt (avoid thick yogurt)\(^a\) made from cow’s milk

13. Green food coloring

14. Food thickener: modified cornstarch, such as Spezante\(^b\) (Boyddorr Nutrition, Chia, Colombia)

15. Bib

16. Straws, 2.5 and 10 cc spoons, 200 cc plastic cups

**MONITORING**

Vital signs measurement before the test

**DURATION**

One hour (includes the installation of equipment, staff preparation, clinical evaluation of the patient, explanation and procurement of informed consent, Case Report Form (CRF) filling and elaboration of the test’s report).

**PROCEDURE FOR THE FEESST**

1. Explain the procedure and its benefits and risks to the patient; obtain written informed consent.

2. Install and check the correct functioning of all the equipment for the test. This includes centering the head camera on the endoscope eyepiece, connecting the head camera to the image processing system, connecting the laser rangefinder, and verifying the light and image quality and functioning of the recording software.

3. Wash hands and don protective elements (i.e. facial mask, gown, cap).

\(^a\) This recommendation has the purpose of facilitating preparation of food consistencies, there are some yogurt consistencies that are very similar to semisolid food (sometimes marketed as Greek yogurt). The yogurt is used as thick liquid (“nectar”) consistency, semisolids are obtained by adding food thickener to the yogurt and thin liquids are obtained by adding water to the yogurt. The different food consistencies are explained in detail below.
4. Place the patient in a seated position. Patients who are unable to sit can be evaluated in a semi-recumbent position.

5. Conduct nasal, mouth, and pharynx inspection. This examination allows the endoscopist to choose the nostril he will use to introduce the endoscope and to detect any abnormalities that could potentially affecting swallowing.

6. Lubricate endoscope using water-soluble gel. The patient will not receive anesthetics, so this step is to avoid any interference with measurements of his reflexes.

7. Remove the patient’s nasogastric tube, if he has one. At the end of the exam, the endoscopist can put the nasogastric tube back in, if needed.

8. Introduce the fiberoptic endoscope through the nostril and the inferior meatus. Inspect the nasal cavity, nasopharynx, oropharynx, larynx, and hypopharynx (Figure 1). Then evaluate the handling, clearance, and characteristics of upper aerodigestive secretions and the functionality of the upper aerodigestive tract during phonation (saying “ee” in English or “ii” in Spanish), breathing (10 seconds of normal breathing and 10 seconds of panting), and dry swallowing (including the frequency of dry swallows). (22, 23)

![Figure 1. Larynx, endoscopic anatomy.](image)

9. During the exam, ensure that the endoscopic view is clear. When the endoscope view becomes foggy, the endoscopist could try injecting air or oxygen through the working channel of the endoscope to clear the view. Avoid suctioning through the endoscope’s working channel, as secretions in the working channel decrease the pressure of the air pulses (further details of air pulses are provided below), compromising the reliability of threshold measurement. Secretions in the working channel may also mix with the air pulses, changing the nature of the stimulus (the stimulus becomes a mixture of air plus secretions) and affecting the reliability of the test. If necessary, the endoscope could be removed for cleaning and then reintroduced.

10. If the epiglottis is backward and does not allow for a view of the glottis, move the epiglottis forward by asking the patient to say “ee” (“ii” in Spanish) or asking him to move his mandible forward. Rate the
amount and clearance of secretions according to Table 1. This table is an aid to describe with precision the most relevant alterations on upper aerodigestive secretion clearance, based on the work of Langmore and Murray.\(^{(22,24)}\) It is different from the Murray scale.\(^{(22)}\)

**Table 1. Upper aerodigestive tract secretion clearance**

<table>
<thead>
<tr>
<th>Rate</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.</td>
<td>Normal: wet pharynx (Figure 2)</td>
</tr>
<tr>
<td>1.</td>
<td>Accumulation of secretions outside the laryngeal vestibule (Figure 3)</td>
</tr>
<tr>
<td>2.</td>
<td>Penetration of secretions: secretions enter into the laryngeal vestibule (Figure 4)</td>
</tr>
<tr>
<td>3.</td>
<td>Aspiration of secretions: secretions pass below the vocal folds into the trachea (Figure 4)</td>
</tr>
</tbody>
</table>

In case of penetration or aspiration of secretions, rate the patient’s reaction according to the corresponding letter:

- A. The patient reacts with coughs or clearing maneuvers
- B. The patient does not react (silent penetration or aspiration of secretions)

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**Figure 2. Normal pharynx (wet).**
Figure 3. Accumulation of secretions outside the laryngeal vestibule.

Figure 4. Penetration and aspiration of secretions.

11. Measure the gag reflex threshold (GRT) twice on each side (right and left) of the pharynx (for four measurements total), according to the GRT protocol (see reflex thresholds exploration).

12. Measure the cough reflex threshold (CRT) twice on each side (right and left) of the pharynx (for four measurements total), according to the CRT protocol (see reflex thresholds exploration).

13. Measure the laryngeal-adductor reflex threshold (LART) twice on each side (right and left) of the pharynx (for four measurements total), according to the LART protocol (see reflex thresholds exploration).

14. Evaluate the patient’s swallowing reflex with water: Administer 0.1 cc of water at the base of the tongue (instilling it through the endoscope’s working channel). If the patient’s swallowing reflex is not triggered by this amount of water, administer 0.5 cc of water. If the patient’s swallowing reflex is still not triggered, increase the amount of water to 1.0 cc. Register the smallest volume of water that triggers the swallowing reflex. If the reflex is not triggered with 1.0 cc of water register as absent reflex.
SENSORY EVALUATION DURING FEESST, REFLEX THRESHOLDS MEASUREMENTS

The LPEER was designed to improve the reliability of the sensory evaluation of the laryngopharyngeal tract. This part of the protocol has detailed instructions on how to perform such evaluation.

During the FEESST, the endoscopist measures LART, CRT, and GRT twice on each side (right and left) of the laryngo-pharyngeal tract using the laryngo-pharyngeal endoscopic esthesiometer and rangefinder (LPEER). The LPEER comprises an air-pulse generator and an endoscopic laser rangefinder (telemeter). The air-pulse generator provides air-pulses as stimuli of different intensities to trigger the laryngopharyngeal reflexes. The endoscopic rangefinder measures the distance between the endoscope tip and the point of stimulus impact over the mucosa and helps to standardize the site, distance and angle of stimulus impact. It also plots a polar grid, which may be used to improve precision in the distance, angle, and site of stimulus impact (Figure 5). The circles and cross of the polar grid can help the endoscopist precisely locate the endoscope tip, as shown in Figure 6. In order to measure the reflex thresholds, then, the endoscopist places the endoscope tip 9 mm from the site of impact (9 mm is the maximum limit of the interval of the rangefinder’s accuracy), pointing at each reflex site of impact.

![Figure 5. Polar grid for the endoscopic laser rangefinder and sight: 1) Polar grid; 2) Image captured from the target surface; 3) Center of the polar grid (coincides with the center of the image captured); 4) Laser spot; 5-10) Circles corresponding to estimated distances between the endoscopic tip and the target surface, with 5) being an estimated distance of 1.78 mm (used to center the endoscopic camera), 6) 3 mm, 7) 6 mm, 8) 9 mm, 9) 12 mm, and 10) 15 mm.](image)

Before starting the series of air pulses, the endoscopist must make sure the area of stimulus impact is free of secretions and the endoscopic view is clear. During the series of air pulses, the patient should be asked to avoid swallowing and to maintain mild protrusion of the mandible. Each series of air pulses has a six-second pause after every fifth pulse to allow the patient to swallow.
**Laryngeal Adductor Reflex Threshold (LART) Measurement**

The LART measurement involves stimulating the mucosa of the laryngeal ring to cause adduction of the vocal cords. To enable the endoscopist to explore the LART, the LPEER delivers 10 air-pulses, each one having a duration of 100 milliseconds (ms) at decreasing intensity, going from 0.7 millinewtons (mN) to 0.04 mN (equivalent to 12 mmHg to 1 mmHg using the Aviv’s method of measurement \(^{25-27}\)) at decrements of 0.07 mN. The air pulses are set to decrease in intensity because in the preliminary work, \(^{3}\) it was found that this facilitated the determination of LART; starting with a supra-threshold stimulus helped to identify the normal movement of the vocal cords during the reflex. For patients with laryngo-pharyngeal hypersensitivity that caused them to gag or cough with a 0.7 mN stimulus, we started the series at 0.3-0.4 mN.

As mentioned, the air pulses are administered every three seconds, with a six-second rest period after every fifth pulse to allow the patient to swallow. The endoscopist explores the LART at a point between the corniculate and cuneiform cartilages, as illustrated in Figure 6. The reflex threshold corresponds to the smallest air-pulse intensity elicited that causes the adduction of the vocal cords.

During LPEER calibration, we established the equivalence of the air pulse intensities using Aviv’s method of measurement \(^{25-27}\) to the intensities of such air pulses using a method of measurement better suited for the air pulses’ geometry, these measurements were expressed in force units (Table 2). We performed this equivalence by measuring the air pulses using Aviv’s sensor system and an analytical balance with a 100 mm pan diameter (Precisa BJ 100M, Precisa Gravimetrics AG, Dietikon, Switzerland). This analytical balance measured the air pulses in mass-force units, which were expressed in millinewtons. We show this equivalence just for the air pulses used during LART measurement because the intensity of the air pulses required for the CRT and GRT, as well as the diameter of such air pulses, make their measurements using Aviv’s sensor system unreliable.
Figure 6. Localization of the endoscope, anatomic landmarks, visual field grid, and laser spot highlighting the site of impact of the air pulses: a) Image for LART and CRT right side exploration, showing the cuneiform cartilage touching the horizontal axis of the grid, the corniculate cartilage touching the vertical axis, and the green laser spot between the cuneiform and corniculate cartilages. The center of the laser spot is on the circle indicating a distance of 9 mm from the endoscope tip. b) Image for LART and CRT left side exploration, showing the border of the cuneiform cartilage touching the intercept of the vertical and horizontal axes, the corniculate cartilage touching the 6-mm circle, and the green laser spot between the cuneiform and corniculate cartilages. The center of the laser spot is in the circle indicating a distance of 9 mm from the endoscope tip. c) Image for right GRT showing the green laser spot lateral to the epiglottis. d) Image for left GRT showing the green laser spot lateral to the epiglottis. The precise localization of the laser spot and anatomical landmarks in relation to the visual field grid allows the endoscopist to standardize the distance, angle, and site of impact of the air pulses on the laryngeal mucosa.
Table 2. Equivalence of mN to mmHg of air pulses for LART determination.

<table>
<thead>
<tr>
<th>mN</th>
<th>mmHg</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.05</td>
<td>1</td>
</tr>
<tr>
<td>0.11</td>
<td>2</td>
</tr>
<tr>
<td>0.18</td>
<td>3</td>
</tr>
<tr>
<td>0.24</td>
<td>4</td>
</tr>
<tr>
<td>0.30</td>
<td>5</td>
</tr>
<tr>
<td>0.36</td>
<td>6</td>
</tr>
<tr>
<td>0.42</td>
<td>7</td>
</tr>
<tr>
<td>0.47</td>
<td>8</td>
</tr>
<tr>
<td>0.53</td>
<td>9</td>
</tr>
<tr>
<td>0.59</td>
<td>10</td>
</tr>
<tr>
<td>0.64</td>
<td>11</td>
</tr>
</tbody>
</table>

Notes: mN: millinewtons

Cough and Gag Reflex Thresholds Measurement

During the CRT and GRT evaluations, the endoscopist should look for the appearance of a cough or gag, respectively, when he stimulates the laryngo-pharyngeal mucosa. In these evaluations, the LPEER delivers 10 air pulses, each one having a duration of 1,000 milliseconds with increasing intensity, from 0.8 mN to 16.5 mN, at increments of 1.6 mN. The equivalent value using Aviv’s method of measurement\(^{(25)}\) would be 7.2 to 52 mmHg, but measuring the air pulses used for the CRT determination with Aviv’s method is not reliable because these air pulses have 10.2 mm of mean diameter, and the diameter of the sensor hole is only 1 mm.\(^{(25)}\)

The air pulses are administered every three seconds. CRT is explored at the same site as LART (Figure 6), and GRT is explored at a point lateral to the epiglottis (Figure 6). In preliminary observations it was noted that these particular sites elicit more consistent reflexes. The thresholds for CRT and GRT correspond to the lowest air pulse that elicits a corresponding reflex (\textbf{once the reflex appears, it is not necessary to continue exploring this particular reflex with air pulses of greater intensity}). To decrease discomfort, the endoscopist should stop the series of air pulses once the subject responds with coughing or gaging. He should give the subject some seconds of rest before continuing the examination.
SWALLOWING EVALUATION DURING THE FEESST

To perform the swallowing evaluation during FEESST, the SLP gives the patient green-colored food of four different consistencies: thick liquid, semi-solid, solid, and thin liquid. The food is prepared with commercial yogurt made from cow’s milk, which has a thick fluid consistency, it is mixed with water to obtain a thin-liquid consistency or with food thickener (modified cornstarch, Spezante®; Boydorr Nutrition, Chia, Colombia) to obtain a semi-solid (puree) consistency. A Graham cracker provides the needed solid-food consistency for the test, and it is covered with green puree to provide the green coloring (Figure 8). All of the foods were colored green with food coloring in order to improve their endoscopic visibility.

The subject receives at least three boluses (here “bolus” refers to the volume of food that the subject receives in his mouth) of every food consistency. The SPL gives the food to the subject using a spoon or, in the case of liquids, using a straw and a cup. The volume of bolus is progressively increased from 2.5 cc to 10 cc.

![Food consistencies used for the endoscopic evaluation of swallowing](image)

**Figure 8. Food consistencies used for the endoscopic evaluation of swallowing:** a) Semi-solid (puree); b) Solid (Graham cracker covered with green puree for coloring); c) Thin liquid; d) Thick liquid. All of the foods were colored green with food coloring in order to improve their endoscopic visibility.
During this part of the FEESST, the SLP performs a clinical examination of the patient’s swallowing, observing how the subject receives and processes food in his mouth, including all aspects of the oral preparatory phase of swallowing that may be evaluated by external observation, such as lip closure, suctioning, and chewing; duration of oral preparatory phase; and the amount of residue left in the oral cavity after swallowing. The alterations of the oral preparatory phase are reported according to Table 3.

### Table 3. Alterations in the oral preparatory phase

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Mouth opening: rated as normal or limited.</td>
</tr>
<tr>
<td>2</td>
<td>Sweeping foods presented in spoon: rated as normal, mild compromise, moderate compromise, or severe compromise.</td>
</tr>
<tr>
<td>3</td>
<td>Straw suctioning: rated as normal, mild compromise, moderate compromise, severe compromise, or not evaluable.</td>
</tr>
<tr>
<td>4</td>
<td>Lip closure: rated according to external observation of lips during food processing in the oral cavity (i.e. looking for food spillage through lips) as normal, mild compromise, moderate compromise, or severe compromise.</td>
</tr>
<tr>
<td>5</td>
<td>Chewing: rated according to external observation of mouth during chewing of food as normal, mild compromise, moderate compromise, or severe compromise.</td>
</tr>
</tbody>
</table>

During the FEESST the SLP also observes the endoscope monitor to see how the patient handles food during the pharyngeal phase of swallowing. The endoscopist also continuously observes the endoscope monitor in order to assess the efficiency and safety of the patient’s swallowing. The endoscopist and the SLP determine by consensus the presence and severity of swallowing abnormalities.

During swallowing evaluation the endoscope tip is placed at two sites:

a. Basal or swallowing observation position: The endoscope tip is just above the epiglottis. The field of view includes the hypopharynx, larynx, and the base of the tongue (Figure 4).

b. Laryngeal approach position: The endoscopist asks the patient to stop swallowing and places the endoscope tip close to the larynx. The field of view includes the laryngeal vestibule, glottis, and subglottic region (Figure 5). This position is useful for seeing if there are any signs of penetration (food residue in the laryngeal vestibule) or aspiration (food residue below the vocal cords) after swallowing.

Before the start of swallowing, the endoscopist places the fiberoptic endoscope at the basal position, and after
swallowing, the endoscopist places it at the laryngeal approach position (Figures 4 and 5).\(^{(28)}\)

**Figure 4. Basal or swallowing observation position:** a) Position of the tip of the endoscope in the upper aerodigestive tract; b) endoscopic view.

**Figure 5. Laryngeal approach position:** a) Position of the tip of the endoscope in the upper aerodigestive tract; b) endoscopic view.

**Alterations in the Oropharyngeal Deglutition Efficiency During FEESST**

The evaluation of swallowing during FEESST includes looking for the following alterations in the deglutition
efficiency:

1. Delay in oral preparatory phase: rated as normal, mild compromise, moderate compromise, or severe compromise.

2. Delay in oral transport phase: rated as normal, mild compromise, moderate compromise, or severe compromise.

3. Food residue in oral cavity after swallowing: rated as no residue, mild residue, moderate residue, or severe residue.

4. Delay in swallowing reflex triggering: rated according to the point at which the swallowing reflex was triggered (4, 24) (Table 4).

5. Pharyngeal contraction: (4, 24) rated according to the degree of pharyngeal contraction (Table 5).

6. Laryngeal elevation during swallowing: rate as normal, mild compromise, moderate compromise, or severe compromise.

<table>
<thead>
<tr>
<th>Table 4. Swallowing reflex triggering</th>
</tr>
</thead>
<tbody>
<tr>
<td>The swallowing reflex is classified by consensus between the endoscopist and the SLP as:</td>
</tr>
<tr>
<td>0. Normal: the swallowing reflex is triggered by the bolus at the base of tongue.</td>
</tr>
<tr>
<td>1. Mild delay of swallowing reflex: the swallowing reflex is triggered when the food has reached the valleculae.</td>
</tr>
<tr>
<td>2. Moderate delay: the swallowing reflex is triggered when food reaches the hypopharynx.</td>
</tr>
<tr>
<td>3. Severe delay: the swallowing reflex is triggered when the food reaches the upper esophageal sphincter.</td>
</tr>
</tbody>
</table>
Table 5. Pharyngeal contraction

The pharyngeal contraction is rated by consensus between the endoscopist and the SLP as:

0. Normal: the endoscopic view disappears completely during swallowing. The food is not seen entering the pharynx, and there is no laryngo-pharyngeal residue after swallowing.

1. Mild to moderate compromise: there is some degree of pharyngeal contraction, but the contraction is not complete and the endoscopic view is not lost during swallowing. The food is seen entering the pharynx, and laryngo-pharyngeal residue may be present after swallowing.

2. Severe compromise: absence of pharyngeal contraction.

Alterations in the Oropharyngeal Deglutition Safety During FEESST

The alterations of swallowing safety that are investigated during the FEESST include:

1. Premature spillage of bolus from the oral cavity towards the pharynx due to soft-palate incompetence.

2. Residue in the pharynx after swallowing: Rated according to the amount of residue (Table 6).

3. Penetration: entrance of material into the laryngeal vestibule. In case of penetration, it is important to observe the patient’s defense mechanism. When the patient coughs or makes a clearing maneuver to clear his larynx, it should be registered as defense present. If the patient does not cough or make any clearing maneuver, this is registered as defense absent (silent penetration).

4. Aspiration: entrance of material below the vocal cords. The degree of aspiration is rated according to the approximate percentage of bolus aspiration (Table 7).

5. The severity of penetration or aspiration is also rated by the penetration-aspiration scale\(^24, 29\) (Table 8), and the severity of dysphagia is rated according to the dysphagia severity scale\(^24\) (Table 9).
Table 6. Residue severity

The presence of residue in the pharyngeal cavity is rated after a bolus of 10 cc is administered to the patient (here bolus refers to the volume of food that the subject receives in his mouth, measured in a 10 cc spoon). To rate residue severity, the relative volume of residue is estimated by consensus between the endoscopist and the SLP, comparing the volume of residue observed in the laryngo-pharyngeal tract to the bolus administered to the patient (approximate percentage of the bolus) as:

0. Normal: absence of residue.
1. Minimum: material coating the pharyngeal walls.
2. Mild: more than coating but less than 10% of a 10 cc bolus (roughly less than 1 cc).
3. Moderate: between 10% and 20% of a 10 cc bolus (roughly 1 cc to 2 cc).
4. Severe: more than 20% of a 10 cc bolus (roughly more than 2 cc).

Table 7. Aspiration severity

The degree of aspiration is rated by consensus between the endoscopist and the SLP, comparing the volume of aspiration observed to the bolus administered to the patient (approximate percentage of the bolus) as:

0. Normal: absence of aspiration.
1. Mild aspiration: aspiration of drops of bolus or any amount lower than 5% of bolus.
2. Moderate aspiration: aspiration of 5% to 10% of bolus.
3. Severe aspiration: aspiration of more than 10% of bolus

In case of aspiration, the defense of the patient is registered as:

A. Present: the patient coughs or make a clearing maneuver to clear his airway.
B. Absent: the patient does not cough or make any clearing maneuver (silent aspiration).
Table 8. The 8-Point Penetration-Aspiration Scale (29,30)

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Material does not enter the airway</td>
</tr>
<tr>
<td>2</td>
<td>Material enters the airway, remains above the vocal folds, and is ejected from the airway</td>
</tr>
<tr>
<td>3</td>
<td>Material enters the airway, remains above the vocal folds, and is not ejected from the airway</td>
</tr>
<tr>
<td>4</td>
<td>Material enters the airway, contacts the vocal folds, and is ejected from the airway</td>
</tr>
<tr>
<td>5</td>
<td>Material enters the airway, contacts the vocal folds, and is not ejected from the airway</td>
</tr>
<tr>
<td>6</td>
<td>Material enters the airway, passes below the vocal folds and is ejected into the larynx or out of the airway</td>
</tr>
<tr>
<td>7</td>
<td>Material enters the airway, passes below the vocal folds, and is not ejected from the trachea despite effort</td>
</tr>
<tr>
<td>8</td>
<td>Material enters the airway, passes below the vocal folds, and no effort is made to eject</td>
</tr>
</tbody>
</table>
Table 9. Dysphagia severity scale (modified from [31, 32]):

<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0. Normal</td>
<td>Normal swallowing mechanism.</td>
</tr>
<tr>
<td>1. Minimum dysphagia</td>
<td>Mild deviation from normal swallowing, patient can report a change in sensation during swallowing, but there is no need to modify the diet.</td>
</tr>
<tr>
<td>2. Mild dysphagia: residues without penetration nor aspiration</td>
<td>Oropharyngeal dysphagia present, but can be treated by mild diet modifications, swallowing maneuvers or behavioral interventions.</td>
</tr>
<tr>
<td>3. Mild to moderate dysphagia: penetration without aspiration</td>
<td>The patient is at risk for aspiration, but the risk can be decreased by specific swallowing techniques and by diet modification. There is a substantial increase on eating time; supplemental nutrition may be indicated.</td>
</tr>
<tr>
<td>4. Moderate dysphagia: aspiration less than 5% of bolus administered to the patient</td>
<td>The patient may eat some food consistencies using specific swallowing techniques to minimize the risk of aspiration or to facilitate deglutition. The patient requires supervision at mealtimes; may need supplemental nutrition.</td>
</tr>
<tr>
<td>5. Moderate to severe dysphagia: aspiration of 5% to 10% of bolus administered to the patient</td>
<td>Aspiration risk can be minimized by specific instructions about deglutition. Cough reflex is absent or is not protective. There is indication of an alternate way of feeding to cover the nutritional needs of the patient; NPO may be indicated.</td>
</tr>
<tr>
<td>6. Severe dysphagia: aspiration of more than 10% of bolus administered to the patient</td>
<td>NPO indicated.</td>
</tr>
</tbody>
</table>

Deglutition Postural Techniques and Maneuvers

When the patient presents alterations in swallowing, the SLP may apply the following maneuvers to see if they are useful for compensation in order to improve swallowing safety and/or efficiency; (20, 33, 34)

a. Chin down (also known as chin tuck or head flexion): The patient tucks his head toward the chest, as much as possible, during swallowing. This technique helps reduce aspiration, especially in patients experiencing aspiration from residue located at the valleculae. (33, 35, 36)

b. Head tilt: This technique is used on patients with unilateral oral or pharyngeal weaknesses to direct food towards the strong side of the mouth. During this technique, the patient tilts his head, trying to touch his ear with his shoulder. (34, 37)
c. Head rotation (also known as head turn): The patient rotates his head to the right or left during swallowing in order to direct the bolus to the side opposite head rotation. This technique may be helpful in patients with unilateral weakness to direct the bolus toward the strong side of the pharynx.\(^{(33, 34, 37, 38)}\)

d. Mendelsohn maneuver: The patient maintains the laryngeal elevation for at least two seconds during swallowing. This maneuver aims to prolong upper esophageal sphincter opening to help patients with decreased laryngeal movement.\(^{(33, 39, 40)}\)

e. Supraglottic swallow: The patient holds his breath before, during, and after swallowing and completes the swallow with a volitional cough. This maneuver is aimed at increasing airway protection in patients with reduced or late vocal-fold closure or delayed pharyngeal swallow.\(^{(33, 36, 39)}\)

f. Super-supraglottic swallow: The patient holds his breath while bearing down before, during, and after swallowing and completes the swallow with a volitional cough.\(^{(39, 40)}\)

g. Effortful swallow: The patient is asked to swallow hard, increasing the tongue-to-palate contact and the pharyngeal squeeze. This maneuver helps to maintain bolus clearance from the valleculae or pyriform sinuses.\(^{(33, 36)}\)

REFERENCES


