Back to Basics: Videofluoroscopic Implementation and Interpretation

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Seminar Outline

• Introduction
• Videofluoroscopic Swallow Study (VFSS)
  – Purpose
  – Reliability
  – Standardizing protocols
  – Determining specific swallowing impairment

Instrumental Examination

• Purpose
  – Evaluate biomechanical and physiologic function and dysfunction
  – Determine swallowing safety
  – Identify effects of compensatory strategies and maneuvers on swallowing
  – Determine appropriate diet

Instrumental Examination-VFSS

• VFSS
  – Direct assessment of oral cavity, pharynx, and esophagus
  – Evaluate what is happening during the swallow without need to infer

• Radiation Exposure
  – Most comprehensive evaluation with the least amount of radiation exposure
  – Radiation exposure (Zammit-Maempel et al., 2007, Lemen, 2004)

Instrumental Evaluation-VFSS

• Patient Positioning
  – Lateral view
  – Allows for documentation of bolus flow and structural movement
    • Fluoroscopic tube focused on:
      – Oral Cavity
      – Pharynx
      – Larynx
      – Cervical Esophagus
  – As patients move, use information from CSE to help direct evaluation

• Patient Positioning
  – A-P view
    • Some clinicians obtain routinely
    • Others obtain only if postswallow pyriform sinus residue is evident in the lateral view
    – Determine if residue is unilateral or bilateral-can be evident in stroke patients
    • Assess vocal fold functioning
      – Have patient say “ah” and identify movement
Instrumental Evaluation-VFSS

• Nasogastric Tube (NGT)
  – Large bore and small bore tubes
    • May affect timing and increase airway invasion
      (Wang et al., 2006; Huggins et al., 1999; Robbins et al.,
      1993) or not (Leder & Sutter 2008)
    • What about residual?
    • Obtain orders prior to VFSS for removal of the
      NGT
    • If NGT appears to be causing or contributing to
      dysphagia, remove tube

Instrumental Evaluation-VFSS

Bolus Presentation Guidelines: My preference

• Self-administered
• Single Swallows
  – 5 ml thin liquid, self-regulated cup sip (or 10 or 20 ml
    measured volume), semi-solid, mastication (generally
    cookie)
  – 2-3 trials volume/consistency (Lazarus et al., 1993)
  – Cued or non-cued swallows?
• Sequential Swallowing
  – Continuous self-administered thin liquid without pause

Instrumental Evaluation-VFSS

Bolus Presentation Guidelines: Suggested
standard (Martin-Harris et al., 2008)

• Self-administered, non-cued
• Single Swallows
  – Lateral view: 5 ml thin liquid x2, thin liquid sequential
    swallows, 5 ml nectar thick, sequential swallows nectar
    thick, 5 ml honey thick, 5 ml pudding barium, ½ barium-
    coated cookie
  – A-P view: 5ml nectar thick, 5 ml pudding barium
• Radiation exposure: 3-5 minutes

Instrumental Evaluation-VFSS

• Bolus Presentation Guidelines
  – If aspiration is evident on the first swallow, generally
    repeat—may need warm-up
  – If consistent aspiration with liquids, initiate
    compensatory strategies
  – If aspiration with liquids and minimal residual, test semi-solids, solids

Instrumental Examination-VFSS

• Therapeutic Strategies
  – Objectively evaluate the effects of compensatory strategies
  – Proceed from least to most restrictive
  – Strategy depends on patient’s cognitive status and real world
    • Posture
    • Maneuver
    • Consistency
    • Sensory input?
**Instrumental Evaluation-VFSS**

- Screen esophagus if significant aspiration is not observed (Martin & Easterling, 2006)
  - Radiologist follows liquid and semi-solid bolus from pharynx to esophagus
  - Radiologist determines if dysfunction and need for further work-up

**VFSS-Interpretation**

- Anatomic abnormalities
- Bolus flow
  - Timing
  - Direction
  - Clearance
- Structural movement-spatial, temporal
- Response to compensatory strategy
- Treatment plan

**VFSS-Interpretation**

- Typically identify symptom-determine pathophysiology
  - Pooling
  - Residue
  - Airway invasion: before, during, or after pharyngeal swallow

**VFSS-Interpretation**

- Oral Phase-dependent upon bolus consistency
  - Containment
  - Mastication/manipulation
  - Transfer

**VFSS-Interpretation**

- Bolus Flow-Timing
  - Oral Transit Time-measured from onset of bolus head or tail movement until bolus head reaches ramus of mandible
  - Stage Transit Duration-measured from bolus head reaches the ramus of the mandible to onset of maximum hyoid elevation
  - Pharyngeal Response Time-measured from onset of maximum hyoid elevation to bolus tail through UES

**VFSS-Stage Transit Duration**

- Onset of Pharyngeal Swallow-transition from oral phase to pharyngeal phase
  - Evoked with leading edge of the bolus in the oropharynx
    - Anterior facial arches
    - Ramus of the mandible bisects base of tongue (mandibular angle)
  - Measured from when the leading edge of the bolus reaches the mandibular angle to onset of maximum hyolaryngeal movement
VFSS-Stage Transit Duration

• Onset of Pharyngeal Swallow
  – During mastication and sequential swallowing, the bolus can be inferior to the angle of the mandible at swallow onset (Dua et al., Palmer et al., Chi-Fishman & Sones, 2000; Daniels & Foundas, 2001; Daniels et al., 2004)
  – Also occurs with single swallows particularly in healthy, older adults (Martin-Harris, Brodsky, Michel, Lee, Walters, 2007; Stephen, Taves, Smith, & Martin, 2005)

VFSS-Interpretation

• Bolus Flow-Direction (airway invasion)
  – Penetration-material enters the laryngeal vestibule
  – Aspiration-material enters the trachea

VFSS-Interpretation

• Bolus Flow-Direction-Timing of Airway Invasion
  – Before the swallow
    • Material enters the airway before onset of the pharyngeal swallow
  – During the swallow
    • Material enters the airway during the swallow
  – After the swallow
    • Material enters the airway after the swallow

VFSS-Interpretation

Penetration-Aspiration Scale
1 – No airway invasion
2 – Laryngeal penetration with clearing
3 – Laryngeal penetration with stasis
4 – Penetration to the TVC with clearing
5 – Penetration to the TVC without clearing
6 – Aspiration with clearing
7 – Aspiration with cough but no clearing
8 – Silent aspiration

VFSS-Interpretation

• Bolus Flow-Clearance
  – Postswallow residual
  – Location
    • Oral cavity
    • Valleculae
    • Pyriform sinus-unilateral, bilateral
  – Consistency
  – Amount (Eisenhuber et al. 2002)
  – Build-up
  – Postswallow airway invasion
VFSS-Interpretation

• Structural Movement
  – Temporal-duration of the actual displacement of a structure, e.g., hyoid, UES opening
    • objective measure with counter timer
  – Spatial-distance of displacement
    • Objective measure with special software

• MBSImp (Martin-Harris et al., 2008)
  – Observed physiology from VFSS
  – 17 components
  – Semi-objective
    • Impression of severity
  – Not available unless attend workshop and training

VFSS-Interpretation

• Pharyngeal Phase- approx 1 second
  – Velopharyngeal closure
  – Laryngeal closure
  – Superior and anterior movement of the hyoid bone and larynx
  – Upper esophageal sphincter (UES) opening
  – Base of tongue (BOT) retraction
  – Pharyngeal constrictor contraction

• Bolus Flow-Timing
  – Characterized in general terms of slow or delayed or objectively quantified
  – Objective requires time code generator
    • Oral
    • Evocation of the pharyngeal swallow
    • Pharyngeal

VFSS-Interpretation

• Radiographic Symptom
  – Preswallow
    • Anterior leakage
    • ↓ bolus formation
    • Pooling into the pharynx
    • Airway invasion-generally before onset of pharyngeal swallow
  – Postswallow
    • Oral residual-may yield airway invasion postswallow

• Physiologic Abnormality
  – ↓ Oroolingual Control

VFSS-Interpretation

• Radiographic Symptom
  – Preswallow
    • Pooling into the pharynx
    • Airway invasion-generally before onset of the pharyngeal swallow but could be during

• Physiologic Abnormality
  – Delayed onset of pharyngeal swallow
VFSS-Interpretation

• Radiographic Symptom
  – Nasal regurgitation
• Physiologic Abnormality
  – Poor pharyngeal motility

VFSS-Interpretation

• Radiographic Symptom
  – Valvular residue: may lead to airway invasion after swallow
• Physiologic Abnormality
  – ↓ BOT to PPW approximation
  – ↓ epiglottic deflection
    • ↓ anterior hyoid movement
    • Intrinsic changes in supportive tissue

VFSS-Interpretation

• Radiographic Symptom
  – Pyriform sinus residue: may lead to airway invasion after swallow
• Physiologic Abnormality
  – ↓ anterior hyoid movement-
    • ↓ UES opening
  – Intrinsic problem with cricopharyngeus relaxation
  – Unilateral pharyngeal hemiparesis
    • If unilateral residue

VFSS-Interpretation

• Reliability in interpretation
  – Like CSE, for VFSS, each group of clinicians should establish:
    • Consistent protocol
    • Reliability in interpretation-inter and intra-rater (Stoeckli et al., 2003; McCullough et al., 2001)

Esophageal Disorders and Dysphagia

Referrals...

• Often referrals for a dysphagia evaluation have primary esophageal etiology
• Referring providers have limited experience in distinguishing esophageal dysphagia from oropharyngeal dysphagia
• Often these patients are evaluated first with a videofluoroscopic swallow study (VFSS) by a Speech Pathologist
ASHA Preferred Practice Patterns

- Swallowing Assessment refers to the review of the deglutitive esophageal phase “…screening of the esophageal phase”
- SLP and Radiologist observations, impressions, and recommendations from the radiographic examination should correlate with patient symptoms
- Esophageal Scan and appropriate referral

Dysphagia

- The subjective location of dysphagia does not always correspond to the anatomical location of the pathology
- Patient’s clinical complaints and reporting regarding the site of dysphagia may be unreliable and does not correlate with actual problem
  - Distal stricture often referred proximally
  (Jones et al., 1989)

Background

Anatomy of the Human Esophagus

The esophagus:
- 22 to 26 centimeters in length
  - Varies with body size
- Distended 2.5 cm – compressed at rest
- Tubular structure composed of skeletal and smooth muscle
- Boundaries: Sphincters = UES & LES

(Christensen, 1987; Roman, 1982)

Clinical Indicators of Possible Esophageal Swallowing Abnormality

- Fullness or tightening in throat or chest
- Localized or radiating Neck, jaw, or chest pain
- Liquid or Solid Food Dysphagia
- Chronic Cough
- Chronic Throat Clearing
- Excessive secretions
- Paradoxical Vocal Cord Dysfunction
- Breathlessness
- Hoarseness
- Sore throat
- Acidic taste

Esophageal Scan or Screen

- What can we evaluate?
  - Position – Misconceptions
    - Gravity
  - Number of swallows
  - Effects of bolus volume
  - Effects of bolus temperature
  - Trials
  - Bolus transit may be complete in the absence of normal esophageal motility!
- Primary peristalsis – swallow initiated
- Secondary peristalsis – esophageal body
- Tertiary contractions – simultaneous non-productive

Esophageal Scan

Esophageal Scan or Screen

- What can we evaluate?
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Esophageal Peristalsis

- Peristalsis in the striated muscle is modified if the bolus volume and temperature change, indicating that sensory inputs from the esophagus modulate the central vagal output that controls peristalsis in the striated muscle of the esophagus
  
  (Dodds, Hogan, Reid, Stewart & Arndorfer, 1973)

Single Swallow:
  Observe primary peristalsis
Frequent Swallows:
  Inhibit Propagation of Peristalsis into the Distal Esophagus

Esophageal Motor Function & Bolus Motility

- 1° peristaltic wave - initiated by swallow
- 2° peristaltic wave - initiated by distended esophagus
  - 2° bolus residual
  - Reflux event
- Tertiary contractions - non-propulsive events
- Manometry and esophagram are complimentary
  - Manometry quantitative
  - Esophagram qualitative

Components of a Radiographic Examination to Evaluate Esophageal Function

- Heavy density Barium
- Recumbent
- Upright
- Sufficient Bolus Size
- Observation of Sufficient Swallows
- Gas crystals
- Abdominal Compression ?
- Bolus Challenge (marshmallow) ?
- Gastroesophageal reflux ?

Some Relevant Physiologic Parameters

- UES Opening Dynamics
  - relaxation
  - traction forces
    - hyoid and laryngeal maximum deglutitive excursion
    - hyoid and laryngeal acceleration
- Bolus Dynamics
  - intrabolus pressure
- UES Compliance

Protective Reflexes
Airway Protective Mechanisms Against Reflux

- Reflexes: response mechanisms
  - Activated by stimulation
    - Esophageal distention
    - Secondary peristalsis
    - Reflexes that prevent retrograde entry into the pharynx
  - Stimulation of the pharynx

Response Mechanisms

- Esophago-UES contractile reflex
  - Prevents retrograde bolus flow to the pharynx
- Pharyngo-UES contractile reflex
  - Prevents retrograde material in the esophagus from traveling to the pharynx

Response Mechanisms

- Esophago-glottal closure reflex
  - Facilitates closure of the vocal folds by esophageal distension
- Pharyngo-glottal closure reflex
  - Facilitates closure of the introitus to the trachea
- Pharyngeal secondary swallow
  - Facilitates airway closure
  - Pharyngeal volume clearance in the absence of oral tongue movement

Classifications of Esophageal Disorders

- Structural
- Inflammatory
- Motor or Functional
- Secondary to other organ dysfunction

UES Structural Dysfunction

- Zenker diverticula can occur in a muscular dehiscence
  - Between the oblique muscle fibers:
    - Inferior constrictor muscle
    - Transverse fibers of the cricopharyngeus muscle
  - Killian triangle

Structural Disorders
Patient Symptom’s

- Dysphagia
- Regurgitation of undigested food hours after eating
- Sensation of food sticking in the throat
- Performs special maneuvers to dislodge food
- Coughing after eating
- Aspiration of organic material
- Unexplained weight loss

Patient’s Symptoms

- Months to years
- Most common – aspiration/cough
- Complications
  - Massive bleeding from the mucosa or from fistulization into a major vessel or trachea
  - Esophageal obstruction
  - Squamous cell carcinoma (SCC) within Zenker diverticulum - rare - 0.3%

Position

- Zenker diverticula extend into the left neck 90% of the time
  - Due to:
    - The slight convexity of the cervical esophagus to the left side
    - More laterally positioned carotid artery on the left side
    - Creating a potential space for the sac

Diagnostic Evaluation

- Standard of confirmatory evaluation is the barium swallow using videofluoroscopy
- This study provides information about:
  - Size
  - Location
  - Character of the mucosal lining of the Zenker diverticulum

Structural Changes that Reconfigure the Gastroesophageal Junction - LES

Hernia

- Occurs:
  - An organ slips through the muscle wall that holds the organ in place
- A hiatal hernia occurs:
  - When the upper part of the stomach pushes through an opening in the diaphragm
  - This opening is called the esophageal hiatus or diaphragmatic hiatus
  - Stomach moves up into the chest
Two Categories of Hernia

1. Sliding: LES protrudes above the diaphragm - 95%
2. Paraesophageal – 5%
   - Gastro-esophageal junction remains where it belongs
   - Part of the stomach is squeezed beyond the opening of the diaphragm into the chest beside the esophagus
   - Hernias remain in the chest at all times

Symptoms of the Paraesophageal Hernia

- Paraesophageal hernias – usually no symptoms
- If symptoms are present they may include:
  - Sudden severe chest pain
  - Radiating chest pain that isn't relieved by taking an antacid
  - Difficulty swallowing
  - Stomach pain
  - Indigestion
  - Nausea
  - Vomiting
  - Retching

Hiatal Hernia Risk Factors

- Increased pressure within the abdomen caused by:
  - Heavy lifting or frequent bending over
  - Frequent or hard coughing, sneezing
  - Pregnancy and delivery
  - Violent vomiting
  - Straining with constipation
  - Obesity

Hiatal Hernia Risk Factors

- Heredity
- Smoking
- Drug use, such as cocaine.
- Stress
- Insufficient dietary fiber
- 20% of population – economically developed countries

Treatment

- Behavioral:
  - Elevate the head of their bed and avoid lying down directly after meals
  - Stress reduction techniques may be prescribed
  - Weight loss
- Medication:
  - Avoid medications that lower the lower esophageal sphincter (or LES) pressure avoided
  - Antisecretory drugs like proton pump inhibitors and \( \text{H}_2 \) receptor blockers can be used to reduce acid secretion

Behavioral Treatment

Limit or avoid foods before bedtime
Avoid chocolate, mint, caffeine, carbonated beverages, acidic foods
Leave a span of approximately 2-3 hr between the last meal and bedtime
Eat smaller and more frequent meals
Smoking cessation
Reduction in alcohol consumption
Do not eat lying down
Do not lie down after eating
Raise the head of the bed with blocks
Encourage weight loss if over weight
Avoid tight garments
Treatment

- Surgery when:
  - Constricted or strangulated
    - Immediate intervention
  - Reduce the hernia - putting it back where it belongs

Nissen fundoplication

- Gastric fundus (upper part) of the stomach is wrapped, or plicated, around the inferior part of the esophagus

- Preventing:
  - Herniation of the stomach
  - Reflux of gastric acid
  - Performed laparoscopically

- Vaezi et al., (2006) Fundoplication does not improve laryngeal symptoms reliably in patients unresponsive to PPI therapy

Proton Pump Inhibitors

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<th>Generic Name</th>
<th>Trade Name</th>
<th>GERD Dosage</th>
<th>Formulation</th>
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<td>Prilosec</td>
<td>20 mg/d</td>
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Proton Pump Inhibitors: AstraZeneca, Wilmington, DE. † TAP Pharmaceuticals, Lake Forest, IL. ‡ Janssen Pharmaceutica, Titusville, NJ. § Wyeth-Ayerst, Philadelphia, PA.

Gastroesophageal Reflux

Gastro-Esophageal Reflux Disease

- Multi-factorial causes:
  - Inadequate anti-reflux mechanism (LES)
  - Volume & potency of refluxed material
  - Esophageal mucosal resistance
  - Esophageal clearance (2º peristalsis)
  - Transient relaxation of the LES (TLESR),
    - Not due to persistent LES hypotension
  - Resultant strictures often distal and 1-4 cm in length

Changes in Oropharyngeal Swallow GERD vs. Normal

- Significant changes in temporal measures:
  - Reduced anterior to posterior tongue movement
  - Delayed pharyngeal response
  - Longer pharyngeal transit time
  - Later onset of hyoid movement
  - Longer UES opening
  - Greater number of swallows per bolus
  - Greater amount of pharyngeal residue
  - Greater incidence of penetration

Mendell & Logemann, Dysphagia, 2002
Symptoms of GER/LPR

Burning sensation in throat or mouth
Acid or sour taste in mouth
Regurgitation of food when swallowing
Coughing when lying down
Coughing in the morning
Frequent throat clearing and/or coughing
Hoarseness, particularly in the morning
Complaints of indigestion, sore stomach, sour stomach
Frequent burping (with and without odor)
Complaints of lump in throat, globus sensation
Laryngospasm

GERD - Behavioral Treatment

Limit or avoid foods before bedtime
Avoid chocolate, mint, caffeine, carbonated beverages, acidic foods
Leave a span of approximately 2-3 hr between the last meal and bedtime
Eat smaller and more frequent meals
Smoking cessation
Reduction in alcohol consumption
Do not eat lying down
Do not lie down after eating
Raise the head of the bed with blocks
Encourage weight loss if over weight
Avoid tight garments

Esophageal Disorders

• Structural
  – Rings (Schatzki)
  – Webs
  – Caustic & inflammatory strictures
  – Intrinsic neoplasm
  – Extrinsic compression (neoplasm, vascular, inflammatory)
  – Congential atresia or fistula

Symptoms – Schatzki Ring

• Most patients present with intermittent, episodic, nonprogressive dysphagia to solids
• Dysphagia for liquids is usually not present
  – Typically, the patient ate a meal in a hurried fashion
  – Forced down by drinking liquids, or regurgitated to relieve the obstruction
    • Then finishes meal
  – Dysphagia may not recur for months or years in these patients

Symptoms – Schatzki Ring

• Daily dysphagia is unlikely to be caused by a Schatzki ring
• Bread (especially freshly baked) and meat appear to be common foods that frequently precipitate symptoms
• Post alcohol and heavy dinner "steakhouse syndrome"
• Associated symptoms of heartburn and regurgitation

Treatment

• Dilation
• Recur within 5 years
• PPI to prevent recurrence
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### Esophageal Disorders

- **Inflammatory**
  - Reflux esophagitis
  - Infection (fungal, viral)
  - Radiation
  - Medication (pill injury)

### Functional or Motor Disturbances

- Non-specific dysmotility
- Breaking 1º peristaltic pressure wave
- 2º clearing - common
- Tertiary contractions – common and increase with age
- Low amplitude of peristaltic pressure wave
- Prolonged duration of peristaltic pressure wave

### Achalasia

- Lack of relaxation of the lower esophageal sphincter (LES)
  - Absent or markedly decreased 1º and 2º esophageal peristalsis
  - Disruption of motility
- Early- “vigorous” numerous tertiary contractions
  - Without normal 1º wave
- Late stage - dilated esophagus
  - Large air-fluid level
  - “Bird beak-like” appearance of the LES
- Amyl Nitrate - smooth muscle relaxant
  - Improves LES relaxation
  - Lowers barium column level
  - Excludes underlying tumor

### Secondary Motility Disorders

- Neurologic disease
  - Parkinsonism
  - Huntington’s chorea
  - Wilson’s disease
- Cerebrovascular disease
  - Multiple sclerosis
  - ALS
  - CNS neoplasm

### Achalasia

- Symptoms/Clinical presentation
  - Dysphagia for solids and liquids
  - Gradual onset but will have symptoms over two years
  - Postural changes
  - Fullness in the chest, regurgitation
  - Undigested food regurgitated
  - Chest pain
    - More common in young
    - Rarely heartburn – fermented food
    - Increased weight loss with duration of the disease
Cases