Accuracy of Dysphagia Assessment and a Review of the Fiberoptic Endoscopic Evaluation of Swallowing

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Many “Leaks” from research & practice

If 80% achieved at each stage then
0.8 x 0.8 x 0.8 x 0.8 x 0.8 x 0.8 x 0.8 = 0.21

Knowledge Gaps between what is known and what is done

- What “gaps” between research and practice are you involved in?
- What “gaps” between research and practice do you recognize in the field of SLP?
The Epidemiology of Ignorance in Health Care

- What do we know about what we know?
  - Prevalence & Incidence
  - Etiology/Causation
  - Prognosis
  - Treatment

Introduction to EBM

- Concept began in England and Canada
- Practitioners of EBM use results from clinical trial studies to guide decisions, actions, in medical practice
- Practitioners do not use peer discussions, experience, intuition, as the only basis for decisions, actions in medical practice
- "Re-align Medicine with Science"

Arguments: Against EBM

- Decisions based on old information
- Disregards value of clinical experience, intuition
- Does not take into account local differences in environment or characteristics of local population
- Will be misused by Health Insurance Companies, National Health Organizations to restrict treatment options.
Arguments: For EBM

- Science = “management of error”
- The only valid foundation for Medical Practice
- Traditional Mode of practice prolongs use of wrong treatments, faulty diagnosis.
- EBM brings best and most current knowledge, gained from worldwide sources, to the diagnosis, treatment of a patient
- EBM guides, does not dictate, practice

Medical Information

Perspective Measurement

- Occurrence of discrete events
  - Aspiration
  - Penetration
- Estimation of Efficiency
- Functional Scaling
  - ASHA NOMs Scales
Background
- Sequelae to Dysphagia
  - Malnutrition
  - Dehydration
  - Aspiration pneumonia

Dysphagia Assessment
- Accuracy consistently called into question
  - Clinical Bedside
  - Questions about false negative/positive and reliability
  - Videofluoroscopy
    - Questions about relation to natural feeding and reliability
  - Laryngoscopic Evaluation of Swallowing (FEES)
    - Questions about limitations of visualization

Reducing Error
- The source of the error is not well defined
  - Presumed to be due to a combination of many factors
    - Unequal skills, training, experience and technique
  - Creation of minimum standards for practicing dysphagia clinicians evidenced
BRS-S
- Boarding Recognition in the area of Swallowing and Swallowing disorders (BRS-S).
- Documentation of highly developed skills
- Advanced education
- Comprehensive examination.
- Only 130 Board Recognized Specialists in Swallowing and Swallowing Disorders
- Almost 30,000 SLPs actively practicing in the area of dysphagia.

Reducing Error
- Large number of SLPs providing services
- Potential complications of swallowing disorders
- Imperative that accurate and reliable tools be available for decision making

Inter and Intrajudge Reliability of a Clinical Examination of Swallowing in Adults
- Reliably identify clinical indicators that correlate with events associated with dysphagia.
- Less than 50% are rated with sufficient inter-and intrainjudge reliability.
Intra- and Interjudge Reliability
McCullough (Cont.)

- **Good Reliability**
  - Oral motor function
  - Vocal quality
  - Visual indication of oral stasis

Laryngeal Palpation

McCullough et al. (cont)

- **Sporadic Reliability**
  - Laryngeal palpation to determine:
    - Delayed swallow
    - Total swallow duration
    - Laryngeal elevation
    - Number of swallows/bolus
    - Penetration/Aspiration
Videofluoroscopic Swallowing Study (VFSS)

- 1971
  - Developed to evaluate oropharyngeal swallowing in PD patients
  - Assess effect of L-dopa treatment
- 2004
  - 99,691 examinations in the outpatient setting
  - 98,685 procedures in hospitals and skilled nursing facilities
  (Center for Medicare and Medicaid Services, 2004)

VFSS Utility

- “Gold-standard” or “criterion” for observation and identification of oropharyngeal swallowing abnormalities
- Testing the effectiveness of direct compensatory interventions
- Observing the long term effect of
  - Rehabilitation
  - Experimental therapies

VFSS Protocol

- Food and liquid mixed with BaSO4
- Swallow viewed under moving x-ray
- Typically adapted to patient needs
- Presentation of food and liquid boluses from safest to most difficult
  - Volume
  - Consistency
Interobserver Variability in Cineradiographic Assessment of Pharyngeal Function During Swallow.

- Good concordance:
  - Zenker’s diverticulum
  - Tracheal penetration
- Lower concordance:
  - Decreased pharyngeal constriction

Inter- and Intrajudge Reliability for Videofluoroscopic Swallowing Evaluation Measures

- 3 judges
- 20 studies
- Good intrajudge reliability for single judge
- Good interjudge reliability
  - binary judgements of aspiration/penetration
- Poor interjudge reliability for all other measures
- Conclusions:
  - Experienced judges can be expected to reliably rate studies over time.
  - Poor reliability between judges

Intra- and Interrater Variations in the Evaluation of Videofluorographic Swallow Studies

- Reliability higher for
  - Normal findings
  - Absence of aspiration
- Reliability lower for
  - Abnormal findings
  - Functional components of the swallow
Intra- and Interrater Variations (cont)

- CONCLUSIONS:
  - VFSS appears more useful for determining which foods a subject can swallow without aspiration than it is for making definitive pathophysiological diagnoses.

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"One of the symptoms of an approaching nervous breakdown is the belief that one's work is terribly important."

Bertrand Russell (1872-1970)

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My Terribly Important Work

- A² VAMC QA Program
  - Internal calibration of Videofluoroscopic Evaluations
  - Surprisingly low reliability
Reliability and Accuracy

<table>
<thead>
<tr>
<th>High Reliability</th>
<th>Low Reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Accuracy</td>
<td>Low Accuracy</td>
</tr>
<tr>
<td>Low Accuracy</td>
<td>Low Accuracy</td>
</tr>
</tbody>
</table>

Accuracy Challenge

- Finding the “right” answers!
- Expert panel review
- Expert panel consensus sessions

Pilot Studies
Pilot Study 1

- 116 SLPs
- Demographic Questions
  - Years Performing Fluoroscopy
  - Number of Procedures per Week
  - Pronunciation of Dysphagia
- Real time review of 16 VFSS segments
  - Anatomy
  - Delay
  - Penetration Aspiration Scale (Rosenback et al. 1996)
  - Pathophysiology
  - Functional Scaling (ASHA NOMS)
- Compared to key of “correct” responses
  - Expert panel

Methods: Stimulus Development

- 34 Questions
  - Anatomy
  - Aspiration/Penetration (scale)
  - Duration of Stage Transition (scale)
  - Efficiency (scale)
  - Pathophysiology
    - What caused delay, asp/pen, etc.
  - Functional Level
    - ASHA NOMs Scale

Subjects: Expert Judges

- Six Judges
- 3/6 university dysphagia instructors
- 5/6 actively train other clinicians
  - Research Protocol Training
  - Workshops
- Average 15 years in field
Subjects: Expert Judges
- All actively performing >7 fluoro exams/week
- Three judges
  - First author of 1-5 peer reviewed journal articles related to dysphagia
- Two judges
  - First author of greater than 5 peer reviewed journal articles related to dysphagia.

Subjects: Practicing Clinicians
- Large group session ASHA 2000
  - “Compare Yourself to the Experts”
- Demographics captured at onset of session
- 116 Subjects met demographic criteria
  - CCC clinicians actively performing videofluoroscopic evaluation of swallowing

Methods: Demographic Questions
- Pronunciation of Dysphagia
- Work Setting
- Years Practicing
- Years Performing Fluoroscopy
- Number of Procedures per Week
- Level of Independence or Supervision
- Self Report of Expertise
- Research Experience
- Level of Education
- Practice Pattern
### Expert Response Summary

<table>
<thead>
<tr>
<th># of Questions (N=34)</th>
<th>Percent Agreement</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>100%</td>
</tr>
<tr>
<td>3</td>
<td>&gt;80%</td>
</tr>
<tr>
<td>12</td>
<td>66%</td>
</tr>
<tr>
<td>17</td>
<td>&lt;50%</td>
</tr>
</tbody>
</table>

### Expert Panel Responses With High Concordance

<table>
<thead>
<tr>
<th>Agreement</th>
<th>Stimulus Item</th>
<th>Targeted Finding</th>
</tr>
</thead>
<tbody>
<tr>
<td>100% (6/6)</td>
<td>Anatomy</td>
<td>Total Laryngectomy</td>
</tr>
<tr>
<td>100% (6/6)</td>
<td>DST</td>
<td>No Extension (normal)</td>
</tr>
<tr>
<td>83.3% (5/6)</td>
<td>Anatomy</td>
<td>No Anomaly (normal)</td>
</tr>
<tr>
<td>83.3% (5/6)</td>
<td>DST</td>
<td>No Extension (normal)</td>
</tr>
<tr>
<td>83.3% (5/6)</td>
<td>Asp/Pen</td>
<td>Normal (no asp/pen)</td>
</tr>
</tbody>
</table>

### Expert Panel Responses With Low Concordance

<table>
<thead>
<tr>
<th>Agreement</th>
<th>Stimulus Item</th>
<th>Finding</th>
</tr>
</thead>
<tbody>
<tr>
<td>33.3% (2/6)</td>
<td>Pathophys DST</td>
<td>Abnormal</td>
</tr>
<tr>
<td>33.3% (2/6)</td>
<td>Pathophys Efficiency</td>
<td>Abnormal</td>
</tr>
<tr>
<td>33.3% (2/6)</td>
<td>Most Striking Feature</td>
<td>Abnormal</td>
</tr>
<tr>
<td>33.3% (2/6)</td>
<td>Recommend Intervention</td>
<td>Treatment</td>
</tr>
</tbody>
</table>
Conclusions: Expert Group
- Greater concordance
  - Absence of disorder
  - Normal findings
  - Dramatic findings
- Lower concordance
  - Abnormal findings
  - Pathophysiology of disorder
- Reliability
  - Very Good when using scales

Large Group Responses With High Concordance

<table>
<thead>
<tr>
<th>Percent in Agreement</th>
<th>Stimulus Item Finding</th>
</tr>
</thead>
<tbody>
<tr>
<td>81.0% (94/116)</td>
<td>Anatomy Total Laryngectomy</td>
</tr>
<tr>
<td>71.6% (83/116)</td>
<td>DST No Extension(normal)</td>
</tr>
</tbody>
</table>

Large Group Responses With Low Concordance

<table>
<thead>
<tr>
<th>Percent</th>
<th>Stimulus Item</th>
<th>Finding</th>
</tr>
</thead>
<tbody>
<tr>
<td>35.3% (41/116)</td>
<td>Anatomy</td>
<td>Abnormal</td>
</tr>
<tr>
<td>33.6% (39/116)</td>
<td>Efficiency</td>
<td>Abnormal</td>
</tr>
<tr>
<td>25.9% (30/116)</td>
<td>Path of Aspiration</td>
<td>Abnormal</td>
</tr>
<tr>
<td>25.0% (29/116)</td>
<td>Most Striking Feature</td>
<td>Abnormal</td>
</tr>
</tbody>
</table>
Correlation in Pilot Data

Table 1. Correlations between Demographics and Total Score

<table>
<thead>
<tr>
<th>Fluoroscopies/Week</th>
<th>Practice Pattern</th>
<th>Total Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pearson Correlation</td>
<td></td>
</tr>
<tr>
<td>Fluoroscopies/week</td>
<td>1.000</td>
<td>-.100</td>
</tr>
<tr>
<td>Sig. (2-tailed) N</td>
<td>.293</td>
<td>.012</td>
</tr>
<tr>
<td>Practice Pattern</td>
<td>-.100</td>
<td>1.000</td>
</tr>
<tr>
<td>Sig. (2-tailed) N</td>
<td>.293</td>
<td>.012</td>
</tr>
<tr>
<td>Total Score</td>
<td>.233</td>
<td>-.009</td>
</tr>
<tr>
<td>Sig. (2-tailed) N</td>
<td>.293</td>
<td>.012</td>
</tr>
</tbody>
</table>

* Correlation is significant at the 0.05 level (2-tailed).

Conclusions: Large Group

- # procedures/week correlated with “accuracy”
- May be attributed to “tuned up” visual processing related to practice
- Heightened vigilance during real time review
- Reliability poor for most difficult discriminations

Pilot Study 1: Conclusions

- # procedures/week correlated with “accuracy”
- May be attributed to “tuned up” visual processing related to practice
- Heightened vigilance during real time review
**Newcastle Data Collection 10-2001**
- Collected data from practicing UK clinicians
  - Individual responses
  - Automated group response
  - Slow motion individual/group response

**Newcastle Responses With High Concordance**

<table>
<thead>
<tr>
<th>Agreement</th>
<th>Stimulus Item</th>
<th>Targeted Finding</th>
</tr>
</thead>
<tbody>
<tr>
<td>100% (38/38)</td>
<td>Anatomy</td>
<td>Total Laryngectomy</td>
</tr>
<tr>
<td>84.2% (32/38)</td>
<td>DST</td>
<td>No Extension (normal)</td>
</tr>
<tr>
<td>84.2% (32/38)</td>
<td>DSTcharac</td>
<td>No Extension (normal)</td>
</tr>
<tr>
<td>76.3% (29/38)</td>
<td>Anatomy</td>
<td>No Anomaly (normal)</td>
</tr>
</tbody>
</table>

**Newcastle Responses With Low Concordance**

<table>
<thead>
<tr>
<th>Agreement</th>
<th>Stimulus Item</th>
<th>Targeted Finding</th>
</tr>
</thead>
<tbody>
<tr>
<td>44.7% (17/38)</td>
<td>Function level</td>
<td>Abnormal</td>
</tr>
<tr>
<td>39.5% (15/38)</td>
<td>Intervention</td>
<td>Abnormal</td>
</tr>
<tr>
<td>36.8% (14/38)</td>
<td>EFF pathophys.</td>
<td>Abnormal</td>
</tr>
<tr>
<td>31.6% (12/38)</td>
<td>EFF pathophys.</td>
<td>Abnormal</td>
</tr>
<tr>
<td>28.9% (11/38)</td>
<td>DST pathophys.</td>
<td>Abnormal</td>
</tr>
</tbody>
</table>
Kappa Real Time vs. Slow

<table>
<thead>
<tr>
<th>Stimulus</th>
<th>N</th>
<th>Kappa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delay</td>
<td>38</td>
<td>.221</td>
</tr>
<tr>
<td>Delay Pathology</td>
<td>38</td>
<td>.461</td>
</tr>
<tr>
<td>PAS</td>
<td>38</td>
<td>.209</td>
</tr>
<tr>
<td>Delay Pathology</td>
<td>38</td>
<td>.062</td>
</tr>
<tr>
<td>PAS Scale</td>
<td>38</td>
<td>.455</td>
</tr>
<tr>
<td>Efficiency Pathology</td>
<td>38</td>
<td>.434</td>
</tr>
</tbody>
</table>

Newcastle Conclusions

- Replication of expert/ASHA pilot data
  - High concordance with normal and dramatically abnormal findings
  - Lower concordance with abnormal findings and findings requiring identification of pathophysiology

Newcastle Conclusions

- Slow motion causes shift in judgments
  - Kappa scores for real vs. slow motion poor
  - Clinicians change their minds after viewing in slow motion!
  - McNemar Analysis
    - Organized shift to changes in scaling
Dublin
Reliability of Real Time vs. Slow Motion Viewing For Scaled Judgments

<table>
<thead>
<tr>
<th>Group</th>
<th># Cases</th>
<th># Items</th>
<th>Chronbach's Alpha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Real time</td>
<td>8.0</td>
<td>6</td>
<td>.2858</td>
</tr>
<tr>
<td>Slow motion</td>
<td>8.0</td>
<td>6</td>
<td>.6039</td>
</tr>
</tbody>
</table>

Dublin
Reliability of Real Time vs. Slow Motion Viewing High and Low Frequency Groups

<table>
<thead>
<tr>
<th>Group</th>
<th># Cases</th>
<th># Items</th>
<th>ICC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Real low frequency</td>
<td>4.0</td>
<td>6</td>
<td>.0000</td>
</tr>
<tr>
<td>Slow low frequency</td>
<td>6.0</td>
<td>6</td>
<td>.5476</td>
</tr>
<tr>
<td>Real high frequency</td>
<td>4.0</td>
<td>6</td>
<td>.2870</td>
</tr>
<tr>
<td>Slow high frequency</td>
<td>2.0</td>
<td>6</td>
<td>.8327</td>
</tr>
</tbody>
</table>

ASHA 2005
Reliability of Real Time vs. Slow Motion

<table>
<thead>
<tr>
<th>Measure</th>
<th>Realtime</th>
<th>Slow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tongue base retraction</td>
<td>.587</td>
<td>.510</td>
</tr>
<tr>
<td>Timing of swallow onset</td>
<td>.511</td>
<td>.730</td>
</tr>
<tr>
<td>Laryngeal Elevation</td>
<td>.577</td>
<td>.744</td>
</tr>
<tr>
<td>Pharyngeal Contractions</td>
<td>.186</td>
<td>.759</td>
</tr>
</tbody>
</table>
Dissertation Question

- Does Slow Motion Review Affect Accuracy of Interpretation of VFSS?
- Main Effect
  - Factor 1: Frequency of practice (Experience) vs. total score
  - Factor 2: Tape format vs. total score
- Interaction effect projection
  - Slow motion review improves scores across groups
  - Slow motion review will have the greatest effect on those with low frequency of practice

Methods

Stimulus

- 6 Videotaped swallow segments
- Reviewed by "expert" panel (N=3)
  - Consensus by panel members for
    - "Correct" response
    - "Second-best" response
### Stimulus

<table>
<thead>
<tr>
<th>Stimulus</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tongue base retraction</td>
<td>1 2 3 4 5 6 7 8</td>
</tr>
<tr>
<td>Pharyngeal contraction</td>
<td>1 2 3 4 5 6 7 8</td>
</tr>
<tr>
<td>Laryngeal elevation</td>
<td>1 2 3 4 5 6 7 8</td>
</tr>
<tr>
<td>Cricopharyngeal opening</td>
<td>1 2 3 4 5 6 7 8</td>
</tr>
<tr>
<td>Airway closure</td>
<td>1 2 3 4 5 6 7 8</td>
</tr>
<tr>
<td>Timing of Swallow onset</td>
<td>1 2 3 4 5 6 7 8</td>
</tr>
<tr>
<td>PAS (Rosenbeck et al. 1996)</td>
<td>1 2 3 4 5 6 7 8</td>
</tr>
</tbody>
</table>

### 8-Point Penetration-Aspiration Scale

<table>
<thead>
<tr>
<th>Score</th>
<th>Description of Events</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>

Scoring

- Subjects scored on two questions:
  - Penetration aspiration scale
    - Awarded 1 point for "correct" response
    - Awarded .5 point for a scaled score one point higher or lower than "correct" score
  - Pathophysiology
    - Awarded 1 point for "correct" response
    - Awarded .5 point for "second-best" response

Video Stimulus Viewing Format

- Real-time Viewing Format
  - Played twice with 5 second pause between

- Slow motion Viewing Format
  - Length of single slow viewing = two real-time viewings

Data Collection

- ASHA Healthcare Conference 2006
- Subjects
  - 133 SLPs
    - Years performing VFSS
    - Frequency of performing VFSS/week
- 2 Sessions
  - 1st Session
    - 3 real-time and 3 slow motion video segments
  - 2nd Session
    - Same stimulus items
      - Randomized order
      - Opposite viewing format from 1st session
Results

Hypothesis #1
- There is an advantage afforded to those clinicians who have a high frequency of practice
Hypothesis #2
- Accuracy is improved by employing slow motion review

Research Hypotheses #3
- Slow motion review will have the greatest effect on those with low frequency of practice.

Means for Real-Time vs. Slow Motion

<table>
<thead>
<tr>
<th>Frequency of VFSS/Week</th>
<th>High</th>
<th>Medium</th>
<th>Low</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>7.5</td>
<td>7.0</td>
<td>6.5</td>
</tr>
</tbody>
</table>

Mean Total Score (Accuracy)
Discussion: Hypothesis #1

- More practiced clinicians routinely outperformed less practiced clinicians in both slow motion and real-time review.

Experience and Accuracy

- Experience and accuracy are frequently paired in the field of radiography.
  - Potchen, Cooper & Sierra (2000)
    - Longitudinally studied radiology resident performance in interpreting chest x-rays
    - Greatest change occurred between the first and second years of residency
    - Stability after 3 years
    - Greatest change being a diminution of false-positive observations

Stability with Experience PAS

- Significant quadratic trend “plateau”
  - middle and high frequency subjects for the PAS questions
- Significant gap between the slow and real-time scores for the low frequency group
- Very little change between the middle and high frequency group when viewing in slow motion and real-time formats
Stability with Experience PAS

- The discriminations necessary to accurately employ the PAS may be acquired more easily through frequent practice

Stability with Physiologic Questions

- Pittman (2000)
  - Distinguishes between errors of perception (detection) and errors of interpretation
  - Errors in interpretation are typically related to deficient knowledge or experience in the integration of perceived findings

Stability and Physiologic Question

- The mean scores for the pathophysiology question were consistently lower than those for the PAS question
- The task of perceiving the movements and signs and then integrating the findings to identify the primary disorder of the swallow (interpretation) is more difficult than tracking the bolus through the airway (detection)
Stability and Pathophysiologic Question
- Many practicing clinicians have never received formal training in the area of dysphagia
- Many accumulate knowledge "on the job"
- Attend continuing education classes or participate in competency based programs
- Few standards for interpretation

Stability Physiological Question
- Many clinicians find utility in employing the VFSS to manage patients without being able to discretely identify the specific nature of the dysphagia
- Manipulate consistencies and direct interventions until swallow looks "normal" or closer to "normal"

Discussion: Hypothesis #2
- Accuracy is improved by employing slow motion review
  - Technical vs. perceptual issues
  - Detection errors during review of an examination are often the result of difficulties related to human visual perception
  (Tuddenham, 1962; Yerushalmy, 1983)
Perceptual Enhancement

- Slow motion in cardiac cine studies
- Videostroboscopy in voice studies
  - Kazi, Prasad, Nutting, Clarke, Rhys-Evans & Harrington, 2006; Shohet, Courey, Scott, & Ossoff, 1995

Perception/detection Issues

VFSS

- Clave et al. (2006)
  - 92 patients with brain damage or neurodegenerative diseases
    - “prolonged swallow response” (>=806 ms)
    - delay in laryngeal closure (>=245 ms).
  - 8 healthy volunteers
    - Normals short swallow response (<=740 ms)
    - fast laryngeal closure (<=160 ms).
  - Less than 1/10th second difference

Preparatory and Oral Phase Impairments

- Cannot hold barium in mouth anteriorly
- Cannot form bolus
- Latency in initiation
- Stasis in buccal sulci
- Stasis in FOM
- Stasis in mid-tongue
- Premature spillage
- Slow oral transit
- Reduced Lip Closure
- Reduced range/coord
- Impaired cog fxn/sexn
- Red lab or buc tenx
- Red tongue shaping
- Tongue scarring
- Red tong or pal cntrl
- Impaired tong mvmnt
Research Hypotheses #3.

- Slow motion review will have the greatest effect on those with low frequency of practice

Means for Frequency Groups

- Means for the cumulative slow and real time scores
- Low frequency
  - 16% improvement
- Middle frequency group
  - 7% improvement
- High frequency
  - 5% improvement

Search and Find vs. Holistic Perception

- Kundel et al. (2007) Mammogram search
- Brain function responsible for facial recognition and brain function involved in recognition of radiographic abnormalities may be linked
- Less-expert observers unable to draw on the initial holistic perception
- Left to search the image to discover image features that may be abnormal
- Concluded that exclusive use of the search-to-find strategies lead to slower identification and more errors
Conclusions

- Performing a greater number of examinations (experience) has an effect on accuracy of judgments
- Modification of the rate of viewing:
  - Improves accuracy
  - Should be employed as part of a “Best Practice” when reviewing VFSS


- Purpose:
  - Contrast the psychometric properties (stability, test-retest reliability, construct, and concurrent validity) of three different means commonly used for evaluating VFSS
  1. Rating the presence or absence of a swallowing disorder
  2. Bethlehem Assessment Scale (BAS)
  3. Biomechanical measures
  - 40 VFSSs of patients with head and neck (H&N) cancer

Frown, Cowen & Kelly, 2008

- 12 swallowing “disorders” were selected on the basis of their reported prevalence
- Judged as “present” or “absent”
- Poor bolus formation: material spreads around oral cavity and/or part of the bolus prematurely spills into the pharynx.
- Prolonged oral transit: more than 1 second between initiation of the oral swallow (first posterior movement of the bolus from the hold position) and the bolus passing through the faucial arches and/or repeated tongue-pumping motion.
- Reduced velopharyngeal closure: velopharyngeal closure is incomplete and/or material enters the nasal cavity and nasal regurgitation seen.
- **Delayed onset of swallow reflex:** the head of the bolus is beyond the point where the lower edge of the mandible crosses the tongue base before the swallow is initiated (the first frame showing laryngeal elevation).
- **Base of tongue (BOT) and/or posterior pharyngeal wall (PPW) weakness:** reduced posterior movement of the BOT with reduced/incomplete contact to the PPW.
- **Reduced laryngeal elevation:** limited superior and/or anterior movement of the larynx during the swallow.

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- **Reduced laryngeal vestibule closure:** incomplete contact of the arytenoid to epiglottic base.
- **Pharyngeal residue:** any portion of the bolus (more than trace) remains in the valleculae and/or pyriforms and/or BOT and/or PPW postswallow.
- **Cricopharyngeal muscle dysfunction:** delayed opening when the bolus reaches the cricopharyngeus and/or residue in the pyriform sinuses after the swallow.

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- **Reduced epiglottic inversion:** absent or incomplete (remains horizontal/does not completely close off the laryngeal vestibule) tilting of the epiglottis during the swallow.
- **Laryngeal penetration:** part of the bolus enters the larynx and remains at or above the level of the vocal folds.
- **Aspiration (including silent aspiration):** part of the bolus enters the larynx and passes below the vocal folds into the subglottis.
Frown, Cowen & Kelly, 2008

- Stability
- Swallow function improved as a VFSS progressed
- Suggests a practice effect
  - Improvement in pharyngeal constriction and/or
  - Increased lubrication within the pharynx
    - Resulting in less pharyngeal residue as the study progressed

Frown, Cowen & Kelly, 2008

- Reliability
- Low reliability for both liquid and semisolid consistencies for:
  - Oral transit time
  - Pharyngeal transit time
  - Pharyngeal delay time
  - Extent of hyoid excursion

Frown, Cowen & Kelly, 2008

- Variability in reliability for measures between trials and consistencies
  - Duration of laryngeal elevation (liquids)
  - Delayed swallow reflex
  - Tongue function (BAS)
  - Soft palate elevation (BAS)
  - Swallow reflex (BAS)
  - Residue in pyriform sinuses (BAS)
  - Duration of BOT-PPW contact
  - Duration of laryngeal vestibule closure
  - Duration of cricopharyngeal opening
  - Extent of vestibule closure, and penetration-aspiration scale
Frown, Cowen & Kelly, 2008

- Factors with a high load
- Factor 1 for semisolids (Pharyngeal Motility)

- *number of swallows required to clear the bolus,*
  - has a high loading on the factor (0.919)
  - but a low intercorrelation with other variables (0.469 with the variable *maximum BOT movement*).

Indicators for Dysphagia

- Timing of onset of Swallow
- Efficiency of propulsion of the bolus
- Adequacy of airway protection

Swallow Timing Onset

- The pharynx converts from an airway to an alimentary tract
- Bolus should not penetrate the airway before the onset of the conversion
Spillage, Leakage, Loss of Oral Control, Yada Yada Yada

- Delayed swallow reflex
  - (Lazarus & Logemann 1986; Veis & Logemann, 1985)
- Delayed pharyngeal response
  - (Robbins & Levine, 1988)
- Pharyngeal delay
- Duration of stage transition
  - (Lof & Robbins, 1990; Robbins, Hamilton, Lof, & Kempster, 1992; Rosenbek, Roecker, Wood, & Robbins, 1996; Rosenbek et al., 1998) and

Duration of Stage Transition

- Time elapsed between
  - Moment of termination of the oral stage
  - Moment of onset for the pharyngeal stage of the swallow.

Duration of Stage Transition

- Arrival of the bolus into the pharyngeal cavity before pharyngeal stage initiation.

  - Conventional wisdom:
    - Early arrival indicative of a “delay”!
Event Markers for Duration of Stage Transition

- **Starting point**
  - The moment the bolus head passes the ramus of the mandible.

- **End Point**
  - The initiation of maximal excursion of the hyoid.

Endoscopic Markers for Duration of Stage Transition

- **Starting point**
  - Bolus head appears at the base of the tongue just superior to the vallecular space

- **End Point**
  - The initiation of “white out”.

Etiology of “Delay”

- Coordinating the reconfiguration of the pharynx, from airway to alimentary tract, is problematic for dysphagic patients.
  - Loss of oral control
  - Impaired sensation
  - Reduced sensorium
  - Bradykinesia (rigidity, weakness etc.)
  - Incoordination
Delayed Swallow

- Head of the bolus arrives in the proximity of the open airway prior to the initiation of the reflexive portion of the swallow and airway protection (Stephen, Tayes, Smith & Martin, 2005).
- Postulation:
  - The longer the delay after the arrival of the bolus into the pharynx, the greater the risk of aspirating the bolus into the lower airway (Perlman, Booth, & Grayhack, 1994).

Delayed Swallow Thin Liquid

- Not cohesive
- Once flowing, follow a path determined by gravity and the least resistance
- Fill whatever cavity or channel is in that flow path until it overflows and another gravitational path is offered.

Delayed Swallow: Puree/Solids

- Slower moving, more cohesive bolus
- Reconfiguration of the pharynx is not as urgent
- Normals allow bolus to level of the vallecula while mastication and advancing several small portions of the bolus to the level of the valleculae before initiating a single pharyngeal swallow (Clave, De Kraa, Arreola, Girvent, Farre, Palomera & Serra-Prat, 2006)
Delay Thin Liquid

- Fill and overflow each structural barrier until
  - The airway is either penetrated
  - Swallow occurs
- Requires close coordination of tongue function and airway closure
- Posterior tongue contributes to the lingual-palatal seal of liquids prior to the initiation of the swallow
- Loss of control of the bolus will result in premature spillage into the lower pharynx

Age and Stage Transition Duration

- Overall duration of the transition has been found to increase with age (Tracy, Logemann, Kahrilas, Jacob, Kobara, & Krugler, 1989). Robbins et al. (1992)
  - Swallowing begins to slow after 45 years of age
  - By age 70 years, swallowing is significantly slower than in younger individuals.
- Steven, Taves, Smith and Martin (2005) found bolus position at swallow onset is highly variable across subjects as well as across trials for any given subject


- Compared Stroke and Normal subjects
- STD correctly predicted the presence of aspiration 75% of the time
- Correctly predicted the absence of aspiration in stroke patients over 93% of the time.
- All aspiration occurred either before or during the swallow of thin liquids.
  - Safe: STD 0.5 - 0.75 second
  - Less Safe: STD <0.9 second
STD as a Measure

- Arbitrary demarcations without scientific basis.
- Perlman et al.
  - Mild Delay
    - Greater than one but less than two seconds
  - Severe Delay
    - Greater than five seconds

STD as a Measure

- Concept of a “delayed” swallow is unformed
- “Delayed Swallow” is a real problem
  - Onset of the swallow or the release of the bolus is not coordinated in a safe way (Leonard & McKenzie, 2006).

- Compared cerebral cortical representation of experimentally induced reflexive swallowing with volitional swallow using fMRI
- Reflexive swallowing
  - Bilateral activity concentrated to the primary sensory/motor regions
- Volitional swallowing
  - Bilateral in the insula and the prefrontal, anterior cingulate and parietooccipital regions in addition to the primary sensory/motor cortex
Kern et al. 2001

- Shared areas:
  - Primary sensory/motor cortex at or near the central gyrus
  - Significant variability in the volume of activated voxels in each of the four cortical regions of interest for both volitional and reflexive swallowing


- 12 healthy adults
  - 6 men
  - 6 women
  - Mean age = 68.83 +/- 7.71 years

Daniels et al. 2007

- VFSS with cue and no cue
  - 5 ml thin liquid from cup
  - 2 trials each

- Measurements
  - Slow motion frame by frame
  - Duration and scores were averaged across the two trials
    - OTT=oral transit time
    - STD=stage transit duration
    - PTT=pharyngeal transit time
    - TSD=total swallow duration
    - Penetration aspiration scale
Daniels et al. 2007

- All swallowing durations and transit times were significantly shorter under the cued condition than the non-cued condition
- STD and PTT were significantly longer in noncued swallow
- May be related to the location of the leading edge of the bolus at the onset of the pharyngeal swallow

Daniels et al. 2007

- Cued swallow:
  - Onset of max hyoid movement occurred with the leading bolus edge superior or adjacent to the ramus
- Noncued:
  - Onset of max hyoid movement occurred with the leading bolus edge level with or inferior to the valleculae

Daniels et al. 2007

- Findings:
  - Cued and non-cued are different!
  - Calls into question the use of the ramus of the mandible as the landmark
  - TSD may be the more valuable timing measure for research purposes
Stephen et al. 2005

Reliability of STD Estimation

- Karnell and Rogus (2005)
- Strong operational definition
- Criterion training
- Calibration
- Good reliability can be achieved
A Delay may not equal An Abnormality

Variability

- The duration of stage transition is a highly variable event both within and across subjects.

- Rosenbek et al. (1996)
  - Single subject
    - STDs of 0.03-6.60 seconds
      - 3ml paste swallows.

The division of oropharyngeal swallowing into stages is an artificial conceptualization of a functionally integrated and dynamic system.

- Robbins et al. Gastroenterology 103;823-829, 1992
Normal Variations


- 15 healthy normals
- No command to swallow
- Light 1000 Calorie Midwestern Meal!
  - Cheeseburger
  - Fries
  - onion rings
  - milk/soda

---

Normal Variations

- Dua et al., 1997 (cont.)

<table>
<thead>
<tr>
<th>Extent of Bolus Dwelling in Pharynx Before the Onset of Swallow</th>
<th>Vallecula</th>
<th>Pyriform</th>
<th>Epiglottal edge</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquid</td>
<td>37%</td>
<td>11%</td>
<td>12%</td>
<td>60%</td>
</tr>
<tr>
<td>Solid</td>
<td>40%</td>
<td>2%</td>
<td>34%</td>
<td>76%</td>
</tr>
</tbody>
</table>

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Normal Variation

- Dwell time before pharyngeal stage

Valleculae
- Liquids = 3.2 sec
- Solids = 2.1 sec

Pyriforms
- Liquids = 1.4 sec
- Solids = 1.5 sec
Normal Variations

- Dwell time before pharyngeal stage (cont.)
- Dwell time

Epiglottal Edge
Liquids = 0.3 sec
Solids = 0.4 sec

Delay vs. Loss of Control

- Material may not be contained in the oral cavity
- Lack of lingual-velar seal prior to onset may result in material entering the pharynx early

Delay vs. Loss of Control (cont)

- To Test:
  - Alter natural feeding/swallow on command
  - Ask patient to hold bolus in mouth without swallowing
  - Monitor for arrival of bolus in pharynx before command to swallow
Efficiency

- Bolus Clearance and Driving Forces
  - Tongue Driving Force
  - Pharyngeal Contraction
  - Pharyngeal shortening/Laryngeal Elevation

Tongue Driving Force

- The pressure produced by the tongue and applied directly to the bolus in the oropharynx.

Bolus Control

- Bolus control and propulsive movements are well-visualized in the lateral projection (Youmans & Stierwalt, 2006)
- Bolus cradled in the oral cavity prior to the initiation of the swallow
- Lateral margins of the tongue will stay in contact with the alveolar mucosa
- Central groove is formed in the tongue to contain the bolus (Lazarus, Logemann, Song, Rademaker & Kahrilas, 2002)
**Tongue Driving Force**
- Tongue forms propulsive chamber
- Forces the bolus from the oral cavity by applying pressure in a progressive, arcing, peristaltic motion.
- Motion starts anteriorly and progresses posteriorly against the hard palate and elevated soft palate (Chen, Peng, Chiou & Tsai, 2002; Shaker, Cook, Dodds, & Hogan, 1988).

**Piston Like Force**
- The base of the tongue flattens and moves anteriorly to provide space for the oncoming bolus (Miller & Sonies, 2001)
- Bolus enters the oropharynx,
- Tongue continues the peristaltic arc
  - Progressively contacting the posterior pharyngeal wall at the tail of the bolus until it is pushed inferiorly to the border of the valleculae.

**Disordered Tongue Base Retraction**
- Low tongue driving force has been found to result in vallecular retention (Dejaeger, Pelemans, Ponette, & Joosten, 1997; Wilson and Green, 2006)
- Amplitude of tongue pressure on the bolus as it is squeezed along the hard and soft palates and posterior pharyngeal wall is reduced (Cheng, Peng, Chiou & Tsai, 2002).
**Visual Signs Tongue Base Retraction**

- Puree and solid food stasis often is seen to fall to the vallecular space
- Multiple swallows are implemented for clearance
- Liquid stasis will fill the vallecular space
  - If of a volume great enough to overflow the vallecular space
    - Will travel, by gravity, alongside the laryngeal vestibule to the pyriform sinuses

**Pharyngeal Shortening/Laryngeal Elevation**

- Pharyngeal Shortening
  - Stylopharyngeal contraction
- Laryngeal elevation
  - Suprahypoid contraction
  - Thyrohyoid contraction

**Hyolaryngeal Elevation**

- Laryngeal elevation is considered one of the most important aspects of the pharyngeal stage of the swallow (Kashima & Kelly, 2005)
- Serves as temporal marker
  - Indicates the onset of the reflexive, brainstem mediated portion of the swallow
- Serves an important physiologic function for airway protection and bolus clearance
Hyolaryngeal Elevation

- As the hyolaryngeal complex elevates
  - Floor of the pharynx elevates with it resulting in a shortening of the pharynx.
- Elevation has two components:
  - Anterior movement
  - Superior movement

Hyolaryngeal Elevation

- Suprahyoid muscles contract after the mandible closes tightly
- Contraction from the immobile mandible allows
  - Vigorous fixation at full contraction of the suprahyoid muscles.
- Fixation of the hyoid and mandible together offer a firm base for the elevation of the thyroid and cricoid cartilages.

Hyolaryngeal Elevation and CP Opening

- The laryngeal cartilages ascend as a result of thyrohyoid contraction
- Cricoid ascends and opens the relaxed upper esophageal sphincter
- Some investigators feel principal function of laryngeal elevation is opening of the upper esophageal sphincter (UES) (Yokoyama, Mitomi, Tetsuka, Tayama & Niimi, 2000)
Objective Measures of Hyoloaryngeal Elevation

- Larynx moves approximately 2 – 2.5 centimeters, from rest to maximum elevation
- Visually tracking hyoid and laryngeal elevation:
  - Inexact (at best!!!)
  - Perlman, Van Daele, and Otterbacher (1995)
  - Correlation analysis comparing subjective and objective assessments of hyoid movement
    - Found that the correlation was not strong.
    - Evaluators were more likely to judge hyoid elevation to be inadequate when the anterior movement component was reduced.

- Exact minimum amount of hyoid and laryngeal elevation necessary to adequately promote epiglottic inversion and UES opening is not known
  - (Chi-Fishman & Sonies, 2002)
- If it were known, it would very likely be difficult to determine the presence of a defect subjectively

Upward and Forward Movement

- Ishida, Palmer and Hiiemae (2002)
  - Hyoid bone moved both upward and forward during swallowing
    - Upward displacement was sometimes very small
    - No correlation between the amplitudes of its upward and forward displacements during the same swallow
    - Amplitude of upward displacement was highly variable
      - Influenced by initial food consistency
      - Swallow order within the masticatory sequence.
    - Amplitude of forward displacement was larger and
Upper Esophageal Sphincter/Cricopharyngeus

- High-pressure zone of the upper esophageal sphincter is not well-visualized during fluoroscopy
- Tight contact of the mucosal walls
- Best way to locate the UES is to identify structures that surround it
  - Below pharyngeal air column
  - Posterior to the arytenoid cartilages

Cricopharyngeus

- High-pressure zone that is approximately 3-4 cm in length (Goyal, 1984; Goyal, Martin, Shapiro, & Speckler, 1993).
- Horizontal fibers of the cricopharyngeus insert into the lower lateral third of the cricoid cartilage
  - Loop posteriorly in an arc
  - Terminates on the opposite side of the cricoid.
- High pressure divides the pharyngeal cavity from the esophageal body.

Cricopharyngeus UES Tonus

- Sphincter remains contracted until the pharyngeal swallow occurs
- Inhibitory brainstem command causes the area of high pressure to become atonic (Hila, Castell & Castel, 2001)
- Allows for the traction being applied from laryngeal elevation to pull the front portion of the sphincter anteriorly and superiorly
- Traction opens the UES and allows for bolus transit through the pharyngo-esophageal border and into the upper esophagus.
UES in Elderly

- Age-related changes in UES function have been observed in the elderly.
- Sphincter opening at the height of the pharyngeal swallow has been found to be diminished in the elderly (Shaw et al., 1995)

UES Dysfunction

- Upper esophageal sphincter disorders can be related to structural or functional problems (Cook, 1993)
- Functional disorders
  - Primary muscle dysfunction
  - Secondary to impaired (reduced) traction forces
  - Incoordination of the application of the traction forces during the propulsion of the bolus

UES Dysfunction

- UES may fail to relax at the height of the pharyngeal swallow
  - May be due to a reduction in the inhibitory signals traveling from the brainstem to the tonic UES.
  - Incomplete relaxation of the UES results in reduced opening of the sphincter when traction is applied during laryngeal elevation.
  - Transit of the bolus from the pharynx to the esophagus will be obstructed
  - This obstruction results in residue remaining in the pharynx, typically in the pyriform sinuses, after the swallow (Dejaeger et al., 1997).
UES Dysfunction

- Irradiation to the UES
  - Fibrosis of the muscles with resulting reduced elasticity
  - Surgical procedures involving the musculature of the UES can result in scarring and similarly reduced elasticity (Murry, Wasserman, Carrau & Castillo, 2005).
  - Newly inelastic musculature may not open to the degree necessary to allow efficient passage of the bolus

CP Bar

- Horizontal fibers of the cricopharyngeus insert anteriorly along the lower third of the cricoid cartilage and course posteriorly at about the level of C5-C6
- Anteriorly projecting “bar” or “cricopharyngeal bar (CP bar)”
  - Often observed along the posterior pharyngeal wall
  - Often identified as being representative of hypertrophy of the cricopharyngeus
  - Patient frequently is without the typical

UES Dysfunction and Visual Signs

- Discerning a dysfunction of the UES is difficult via fluoroscopy alone
  - Need manometrics to make a definitive determination.
- Must infer a structural or functional disorder based on the presence or absence of residuals in the distal pharynx combined with the presence or absence of hyo-laryngeal elevation (Dejaeger et. al. 1997).
Pharyngeal Constrictors

- The pharyngeal constrictors are comprised of three obliquely positioned muscles that are stacked and layered from the mandible to the cervical esophagus.
- Superior (cranioaryngeus)
- Middle (hyoaryngeus)
- Inferior (thyroaryngeus)
  - Contract sequentially during the propulsion of the bolus through the pharynx (Hiss & Huckabee, 2005; Van Herwaarden, Katz, Gideon, Barrett, Castel, Achem & Castell, 2003).

Pharyngeal Contraction Function

- Many feel role pharyngeal contraction not so much to propel the bolus as it is to create the rigid walls against which the tongue base applies pressure (Feinberg, 1993; McConnel, Hood, Jackson, & O’Connor, 1994).

Pharyngeal Contraction Function

- Pharyngeal walls and tongue base contact one another as the tail of the bolus is pressed through the oropharynx
- As the bolus tail passes beyond the tongue to the level of the larynx
  - Inferior constrictors contract and clear the bolus into the now opened pharyngo-esophageal segment
Pharyngeal Contraction Movement

- Can be monitored in either the lateral or AP projections
  - Lateral projection
    - Rapid, fleeting impression of a wave that moves superiorly to inferiorly along
      - anterior surface of cervical vertebral bodies
      - posterior border of the barium column
    - Movement sometimes is difficult to discern (Fujiu & Logemann, 1996).
  - When visualized
    - Anterior movement of the posterior pharyngeal wall is
      the result of the compounding of lateral tissue as it
      bunches along the cervical raphe.

Pharyngeal Contraction Function

- Pharynx moves superiorly to
  - trap the bolus
  - constrict sequentially to force it down to the open esophagus
- Radio-opaque markers placed on the posterior pharyngeal wall move
  - Superiorly early in the pharyngeal stage of the swallow
  - Inferiorly once the bolus passes by (Palmer, Tanaka, & Sievens, 1988)

- Superior movement could be due to the
  constriction of the longitudinal muscles of the pharynx
- Salpingopharyngeus
- palatopharyngeus
- stylopharyngeus
- These muscles, when contracted, contribute to the shortening of the pharynx
Rating Pharyngeal Contractions

- No specific parameters available for the objective determination of impaired pharyngeal wall motion (Bulow, Olsson & Ekberg, 2002)
- Often inferred from other signs
  - Presence and location of retained bolus
  - Tongue driving force and pharyngeal constrictor rigidity are symbiotic
    - effect of either is diminished in the absence of its physiologic partner.

Airway Closure

- During the swallow, the pharynx is reconfigured from a respiratory tract to an alimentary tract (Kahrilas, Lin, Chen, & Logemann, 1996)
- Laryngeal airway can be compromised at any time before, during, or after this alimentary reconfiguration and return to respiration
- Several components of the swallow that are related to airway protection
  - Laryngeal elevation
  - Glottal closure

Glottic Closure

- Glottic closure is not well-visualized with fluoroscopy
- AP view gives fair impression of true vocal fold and ventricular fold movement toward the mesial plane
- Lateral projection allows observation of anterior tilting of the arytenoid cartilages, and contact of the arytenoids to the base of the epiglottis base during laryngeal elevation
- Tight, complete vocal fold adduction is not well-visualized (Shaker, Dodds, Dantas, Hogan, & Arndorfer, 1990)
- Surety of the absence of tight closure is verifiable only when contrast material passes below the level of the folds (aspiration)
**Glottic Closure**
- Final movement seen during the pharyngeal stage of the swallow
  - occurs just before UES opening
  - Lasts for approximately 0.6-0.7 seconds (Dodds, Stewart, & Logemann, 1990)
- Lateral projection
- Closure is observed as a forward tilting of the arytenoids
  - Apex of laryngeal elevation
  - Arytenoids will be observed to contact the base of the epiglottis
  - Inverted epiglottis wrapping over the top of the tightly closed vestibule
- Margins of the different tissues are identified variably during a swallow with bolus contrast (Kendall, 2002).

**Airway Protection and Aspiration**
- Primary defect leading to the entry of food or liquid into the airway is the incoordination of reconfiguration (Kahrilas et al., 1997)
- Incoordination often related to poor CNS coordination
  - Reduced afferent input to the CNS
  - Weakened or slowed responses to CNS motor commands.

**Laryngeal Closure**
- Laryngeal closure prevents entry of the bolus into the trachea during the swallow.
- **Conventional wisdom:**
  - Closure is ordered and redundant; inferior to superior
  - True cords first
  - False cords second
  - Anterior movement of arytenoids third
  - Epiglottal downfolding last redundant closure
Airway Closure
Shaker et al. (1990)

- Glottal closure patterns associated with swallowing.
- Type 1: The vocal folds are observed to remain in contact along their entire length after laryngeal elevation is initiated. 58%
- Type 2: The vocal folds are in contact in the anterior half of their length but slightly separated in the posterior portion, leaving a small gap. 7%
- Type 3: The vocal folds are not in contact with each other, leaving a small, elongated triangular opening between the folds. 35%


- 1452 patients referred for dysphagia assessment
- Overall incidence
  - 5.6% (81 of 1452 patients)
  - Unilateral right 31% (25 of 81)
  - Unilateral left 60% (49 of 81)
  - Bilateral 9% (7 of 81)
- Liquid bolus aspirated more often than puree or solid


- 64 Patients with ULVCI:
  - Left-sided (53 cases)
  - Thoracic or cardiac surgery (53.1%)
  - Malignancy (15.6%).
- Significant risk for penetration and aspiration.
- Aspiration tends to occur after the swallow secondary to bolus retention
  - Penetration
    - 20 patients (31.3%)
  - Aspiration
    - 15 patients (23.4%)
Bhattacharyya et al. 2002

- Median PAS score improved from 4.0 to 3.0 post vocal cord medialization procedure
  - 6 laryngoplasties
  - 17 vocal cord injections
  - Laryngoplasty not more successful than vocal cord injection in resolving aspiration (p = .27).
  - Vocal cord medialization may not be as effective as thought for eliminating aspiration in these patients.

Nayak, VK, Bhattacharyya, N, Kotz, J, Shapiro, J (2002) “Patterns of swallowing failure following medialization in unilateral vocal fold immobility” Laryngoscope 112: 1840-1844

- Sixty-seven Patients w/ UVCI
  - 14 laryngoplasties
  - 53 vocal cord injections
  - 83.6% Left sided
  - 74.6% postsurgical iatrogenic paresis
  - Swallowing dysfunction in 74% of patients
    - 44.8% Penetration
    - 29% Aspiration

Nayak et.

- Factors significantly associated with penetration and aspiration
  - Swallow delay (P = .001, Wilcoxon ranked pairs test)
  - Reduced laryngeal elevation (P = .001)
  - Bolus retention in the valleculae (P = .002)
  - Pyriform sinus (P = .001)
  - Posterior pharynx (P = .008).

- Conclusions:
  - Aspiration even after medialization procedures
Efficiency

- Bolus Clearance and Driving Forces
- Tongue Driving Force
- Pharyngeal Contraction
- Pharyngeal shortening/Laryngeal Elevation

Oropharyngeal Swallowing Efficiency

- $100 - \left(\% \text{ residue} + \% \text{ aspiration before or during the swallow}\right)$
- Oropharyngeal transit duration

Another way of calculating OPSE:

- $\%$ Bolus transported into the esophagus
  - $\frac{\text{OTD} + \text{PTD}}{\text{OTD}}$

Laryngoscopic Evaluation of Swallowing

- FEES
- FEEST
- BEST
- VEED
**Flexible Fiberoptic Laryngoscopy**

- Sawashima & Hirose (1968)
- First application to swallowing
  - Langmore, Schatz and Olsen (1988)

**Components of the FEES Assessment**

- Identification of:
  - Normal and abnormal anatomy
  - Discrete structural movements
  - Temporal coordination of anatomic movements relative to bolus advancement
  - Trajectory of the bolus through the pharynx

**Components of the FEES Assessment**

- *Evaluation of the efficacy for:*
  - Adjustments to:
    - Bolus volume
    - Consistency
    - Rate of delivery
  - Adjustments in positioning
  - Implementation of maneuvers
Results of a FEES Exam

- Report of procedure should include:
  - Description of dysphagia:
    - Attempt to pinpoint pathophysiology
    - What specific problems were seen, with what consistencies?
    - What therapeutic alterations helped safety and/or efficiency of swallow?

Results of a FEES Exam (cont.)

- Recommendations
  - PO diet indicated?
    - If yes, what consistencies are safe?
      - Any postures, maneuvers, other alterations indicated?
    - Is direct therapy by SLP indicated?
    - Other recommendations/ referrals

Protocol

- The examination is broken into two sections:
  - Part One
  - Observation:
    - Occurs during the initial passage of the endoscope and is reserved for:
      - The survey of anatomy
      - Elicitation of anatomic movements
      - Observation of secretion management
      - Monitoring of spontaneous swallows
Protocol (cont.)

- Part Two
- Presentation of food and liquid:
  - Various consistencies of food are presented
  - Interventions are attempted

Food Preparation

- Use food from tray
- Observe natural feeding
  - Rate
  - Means of delivery
    - Nosey cups
    - May need to use straws
- Use light colored foods
  - Milk
  - Mashed potatoes

Laryngoscopic Evaluation of Swallowing

- Sensitivity and specificity compares favorably with fluoroscopy
  - (Langmore, Shatz & Olsen, 1988, 1991)
- Replications and similar studies
- Reliability
  - Aspiration/Penetration Scale
    - Colodny (2003)
  - Identifying pathophysiology
    - Probably poor
<table>
<thead>
<tr>
<th>Langmore, Shatz &amp; Olsen</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>First application to swallowing</strong></td>
</tr>
<tr>
<td>- Fiberoptic Endoscopic Evaluation of Swallowing</td>
</tr>
<tr>
<td>- Description of procedure</td>
</tr>
<tr>
<td>- No data</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Langmore, S., Schatz, K. &amp; Olson, N.</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Endoscopic and videofluoroscopic evaluations of swallowing and aspiration.”</td>
</tr>
<tr>
<td><strong>Compared FEES to VFSS in 21 Patients</strong></td>
</tr>
<tr>
<td><strong>Specificity good</strong></td>
</tr>
<tr>
<td>- Premature spillage</td>
</tr>
<tr>
<td>- Residuals</td>
</tr>
<tr>
<td>- Laryngeal penetration</td>
</tr>
<tr>
<td>- Aspiration</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>“Evaluation of swallowing safety with fiberoptic endoscope: Comparison with videofluoroscopic technique.”</td>
</tr>
<tr>
<td><strong>Compared FEES &amp; VFSS in 28 patients</strong></td>
</tr>
<tr>
<td><strong>14.4% disagreement</strong></td>
</tr>
<tr>
<td>- Penetration</td>
</tr>
<tr>
<td>- Aspiration</td>
</tr>
<tr>
<td>- FEES identified aspiration and penetration</td>
</tr>
<tr>
<td>- MBS did not</td>
</tr>
</tbody>
</table>

- Compared FEES & VFSS
  - 56 Patients
  - 96% agreement on silent aspiration

**Videofluoroscopy vs. Laryngoscopy**

  - 39 patients with neurogenic dysphagia
  - found high agreement between the results of videoendoscopic and videofluoroscopic studies

**Schroter et al. (cont)**

- Laryngoscopy
  - Superior for detecting aspiration of saliva
  - Fails to provide sufficient information regarding
    - Cause of the observed symptoms
    - Amount of aspirated material.
Schroter et al. (cont.)

- Six patients exhibited structural changes
  - diverticula, pouches
  - unexpected functional esophageal disturbances
  - retrograde peristalsis

Schroter et al. (cont.)

- Videofluoroscopy allowed for examination of salient findings and structural changes
- Conclusions:
  - The two methods should be considered complementary.


- Case Series
  - Three children type 1 laryngeal cleft
  - Predominant presenting signs and symptoms
    - Cough with ingestion of liquids
    - Posterior to anterior aspiration
    - Through interarytenoid space
Accuracy of Dysphagia Assessment … - Joseph Murray, PhD, CCC-SLP, BRS-S


- Case Study
  - Single subject
    - Large Left MCA CVA
- Serial FEES exams
  - 6 FEES exams over 18 days
- Close monitoring
  - Quick transition to oral intake

Specific Application to H&N Ca


Teguh et al. 2008

- Related dose relationship between the RT received by paryngeal structures and findings of FEES
- Method
  - Swallowing muscles were delineated
    - Mean dose per muscle calculated using the original 3D CT-based treatment plans
  - Regression analysis performed between FEES
    - variables doses in the different swallowing muscles
data dysphagia related questionnaires
    - M.D. Anderson Dysphagia Inventory
    - EORTC H&N35
Teguh et al. 2008

- Results:
  - Significant relationship between results of FEES and the mean dose in the superior constrictor muscle (SCM)
  - Subjective complaints were significantly correlated with the FEES observations

- Conclusion
  - A higher dose in the SCM generally results in worsening of observations during FEES examination

Medical Model: Assessing Reflux

- More than one accepted assessment!
- Ba Swallow
- 24 hour pH probe
- Esophagogastroduodenoscopy (EGD)
- Laryngoscopic manifestation of LPR
- Empirical

How Does One Choose?

- Projection of possible findings from clinical will guide the choice of instrumentation.

- The field of view should determine the instrumentation to be used.

- Choose the instrument that will provide a field of view that reveals the most salient findings.
Indications for Laryngoscopy

- Signs or symptoms of laryngeal penetration or aspiration before the swallow is initiated
- Abnormal vocal quality and suspected dysphagia.
- Increased difficulties with swallowing over the duration of a meal secondary to fatigue.

Indications for Laryngoscopy

- Hypernasality and suspected nasal regurgitation.
- Need for visualization of the hypopharynx/larynx for biofeedback education and/or rehabilitation.

Indications for Laryngoscopy

- Documented pharyngeal dysphagia on videofluoroscopic swallow study (VFSS) that can be retested with endoscopy to:
  - Monitor progress.
  - Better assess underlying etiology.
  - Limit radiation exposure.
Indications for Laryngoscopy

- Suspected or observed difficulty swallowing saliva/oral secretions.
- Difficulty with coordinating suck/swallow and breathing
- Inability to tolerate barium (e.g., potential allergy or aversion to barium).
- Safety issues associated with radiation exposure (e.g., women with confirmed or possible pregnancy or patient who has radiation limitations).

Indications for Laryngoscopy

- Difficulty transporting patients to the radiology suite
  - bedridden or weak patients
  - patients with open wounds, contractures, or pain
  - patients with quadriplegia or wearing a halo
  - patients with obesity or positioning difficulties
  - patient on Intensive Care Unit monitors or ventilators.
- Limited access to radiologic assessment.

Limitations of Laryngoscopy

- Often must infer the disordered physiology of the swallow.
- Cannot see cricopharyngeal function or striated esophagus.
- Important events occur as the view is obscured (during white-out).
- Patient’s anatomy may not allow for an adequate view.
Potential contraindications for use of FEES

- Severe agitation and possible inability to cooperate with the examination.
- Acute cardiac problem.
- Certain patients may require clearance from their medical team prior to the examination.
- History of vasovagal episodes or a history of fainting.
- Severe movement disorders (dyskinesia).

Potential contraindications for use of FEES

- Severe bleeding disorders and/or recent severe epistaxis (nosebleed).
- History of recent acute facial fracture.
- Bilateral obstruction of the nasal passages.

Indications for Fluoroscopy

- Patients being seen for the first time with long-standing dysphagia
- Vague complaints and/or confounding signs during the clinical examination
- Oral stage impairments not fully understood following the clinical examination
Indications for Fluoroscopy

- Anticipation of severely inefficient pharyngeal stage
- Patients with complaints of food being “stuck” at the level of the thyroid notch or below
- Patients with obvious signs of upper esophageal or esophageal dysphagia

Strengths of Fluoroscopy

- Most comprehensive view available
  - Can visualize all of the main structures in one image
  - Can follow bolus from mouth to esophagus
- Non-invasive
- Widely practiced and accepted
  - Large body of supporting literature

Limitations of Fluoroscopy

- Radiation exposure
- Time limited study
  - due to radiation exposure
- Unnatural replication of feeding
  - Taste
  - Viscosity
Limitations of Fluoroscopy

- Positioning difficult for many patients
  - Obese patients
  - Movement disorders
- Staffing and scheduling requirements

Conclusion

- Perform a full clinical exam before choosing.
- Choose exam that you will allow for visualization of the findings.

Assessing Secretions

- Contributing factors for accumulation of secretions:
  - Reduction in the frequency of swallowing
  - Reduction in the amplitude of the pharyngeal swallow
  - Combination of reduced frequency and weakness.
- Highly predictive of aspiration of food and liquid later in the examination
Significance of Accumulated Secretions

- Murray J, Langmore S, Ginsberg G, Dostie A.  

- **Subjects**
  - 47 elderly hospitalized patients
  - 17 normal nonhospitalized elderly subjects
  - 5 younger normal subjects

Murray et al. 1996

- **Methods**
  - Flexible endoscope passed to HP
  - Observations for 2-5 minutes while assessing anatomy, airway protection (hold breath, phonate, etc.)
  - before delivery of any food, liquid
  - Also, noted frequency of spontaneous swallowing

Secretion Severity Rating Scale

- **Results**

<table>
<thead>
<tr>
<th>Rating</th>
<th>Aspiration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hospitalized elderly</td>
<td>0 - 3</td>
</tr>
<tr>
<td>Normal elderly</td>
<td>0,1</td>
</tr>
<tr>
<td>Normal young</td>
<td>0,1</td>
</tr>
</tbody>
</table>

*p* ≤ .001
Hospitalized Subjects’ Secretions Ratings and Subsequent Aspiration of Food/Liquid

<table>
<thead>
<tr>
<th>Rating of secretions</th>
<th>No. of subjects</th>
<th>Aspirated</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>14</td>
<td>3 (21%)</td>
</tr>
<tr>
<td>1</td>
<td>15</td>
<td>8 (53%)</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
<td>5 (100%)</td>
</tr>
<tr>
<td>3</td>
<td>13</td>
<td>13 (100%)</td>
</tr>
</tbody>
</table>

Secretions (cont.)

- Performed Laryngopharyngeal sensory Testing (LPST) for 100 pediatric patients

Secretions (cont.)

- Presence of pooled secretions in children with a feeding or swallowing disorder
  - Predisposes laryngeal penetration and aspiration during feeding.
- Pooled secretions correlated with a history of pneumonia
- Significant difference in the amount of pooled secretions
  - corresponds to an incremental increase in the LPST.
<table>
<thead>
<tr>
<th>Finding</th>
<th>Secretions</th>
<th>Absent LAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laryngeal Penetration</td>
<td>&lt;.0001</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Aspiration</td>
<td>&lt;.0001</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>&lt;.0001</td>
<td>&lt;.004</td>
</tr>
<tr>
<td>Neurologic Disorder</td>
<td>&lt;.002</td>
<td>&lt;.0001</td>
</tr>
</tbody>
</table>

Secretions (cont.)

- Secretions in the vestibule should be an immediate visual marker for potential poor performance during the examination.
- Link et al. (2000) Suggest this is a marker for poor outcome (pneumonia).
- Proceed cautiously:
  - 1cc ice chips first be presented in lieu of food or liquid.

- Replication of Murray et al. (1996)
- 5-point scale
Donzelli et al. 2003

- Secretions in vestibule
- Correlated highly to aspiration
  - Spearman’s = .516 p<.0001
- Correlated to diet recommendations
  - Spearman’s= .720 p<.0001
- Patient’s with trach tubes more likely to score high on scale
  - Spearman’s=.446 p<.0001

Swallow Frequency

- Dry swallows are identified by looking for events of “white out,” or screen obliterations.
- Count the number of dry swallows observed during the first few minutes after the placement of the endoscope and before the offering of food or liquid.

Swallow Frequency (cont.)

- Swallowing Frequency
  - waking hours  0.612 swallows/minute
  - during sleep  0.088 swallows/minute
    - (Lear, Flanagan, & Moorrees, 1965).
- The urge to swallow is related generally to the accumulation of secretions in the pharynx.
Secrecion severity rating scale (cont.)

- Frequency of spontaneous swallowing
- Swallows/min
- Hospitalized elderly 0.89
- Normal elderly 2.82
- Normal young 2.96
  * p < 0.001

Hospitalized Subjects' Aspiration Status and Swallowing Frequency

<table>
<thead>
<tr>
<th>Aspirated</th>
<th>Did not aspirate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Swallowing frequency</td>
<td>0.72</td>
</tr>
<tr>
<td>p = 0.047</td>
<td></td>
</tr>
</tbody>
</table>

Secrecions (cont.)

- Secrecions in the vestibule should be an immediate visual marker for potential poor performance during the examination.
- Link et al. (2000) Suggest this is a marker for poor outcome (pneumonia).
- Proceed cautiously:
  - 1cc ice chips first be presented in lieu of food or liquid.
Penetration-Aspiration

- Score the events associated with penetration or aspiration according to the 8-point scale developed by Rosenbek et al. (1996) (Table 4-8).
- The traditional description of penetration and aspiration is used when employing this scale.

- Penetration - The passage of material into the laryngeal inlet without passing below the level of the true vocal folds.
- Aspiration - The passage of material below the level of the true vocal folds.

8-Point Penetration-Aspiration Scale

<table>
<thead>
<tr>
<th>Score</th>
<th>Description of Events</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>


- Replication of Rosenbeck et al (1996)
- Questions
  - What is overall reliability of PAS using FEES?
  - What are the reliabilities of individual scale scores with FEES?
- Used laryngoscopic images
  - 79 Swallows
  - 4 judges

Colodny (2002)

- 79 Swallow events
  - 70% CVA or other neurologic disease
  - 30% COPD and/or dementia
- 10 events from each category (1-3, 5-8)
- 9 events from category 4
  - Difficult to find event 4
  - Material enters the airway, contacts the vocal folds, and is ejected from the airway

Colodny 2002 (cont)

- Interrater comparisons
  - Compared agreement and disagreement among the four judges on the five indicators of penetration and three indicators of aspiration
  - $\chi^2$ analysis
    - No significant differences between penetration and aspiration indicators
      - $\chi^2 < 0.03$
Colodny 2002 (cont.)

- Conclusions
  - Intra and Interjudge reliability high
  - Higher than Rosenbeck et al. (1996)
    - Exception of scale scores 7&8
  - Increased reliability of middle categories
  - FEES better at discriminating between penetration scores
  - While adequate VF better at discriminating between aspiration scores

Colodny 2002 (cont)

- Conclusions
  - Reduction in discrimination of aspiration scores
  - White out
  - Increased discrimination of penetration scores
    - Laryngeal vestibule well visualized


- 15 Simultaneous VFSS and FEES
- Distributed to 15 practicing endoscopists
- Rated using PAS (Rosenbek et al. 1996)
  - Scored 30 recordings
  - 1800 Scores
  - Scored same studies in randomized order one week later
  - Inter and Intrarater Weighted Kappa
Kelly et al. (2007)

- Inter-rater Reliability
  - VFSS 0.67
  - FEES 0.63
- Intra-rater Reliability
  - VFSS 0.79
  - FEES 0.73

Kelly et al. (2007)

- Clinicians perceived greater severity when scoring FEES than VFSS

Mean Penetration/Aspiration Score

<table>
<thead>
<tr>
<th>Examination</th>
<th>Mean PAS</th>
</tr>
</thead>
<tbody>
<tr>
<td>VFSS</td>
<td>2.47</td>
</tr>
<tr>
<td>FEES</td>
<td>3.61</td>
</tr>
</tbody>
</table>

ANOVA F=296, P < .01

Kelly et al. (2007)

- Conclusions
  - Rater's judgment of the severity of the penetration or aspiration is affected by the type of examination performed
  - Raters consistently scored FEES higher on the PAS scale than VFSS
  - Serious implications for the interchangeable use of these examinations in clinical practice
Calibration VFSS/FEES

Residue Detection (Kelly, 2006)
- Pharyngeal residue rated as:
  - None
  - Coating
  - Mild
  - Moderate
  - Severe

Residue Detection (Kelly, 2006)
- Prospective, single-blind assessment
- Simultaneous videofluoroscopy and FEES recordings
- Raters blinded
  - pairing of the videofluoroscopy and FEES
  - other raters' scores
- 15 Patients
- Simultaneous VFSS and FEES
Residue Detection
(Kelly, 2006)

- Studies scored twice by all raters
- Intra- and inter-rater agreement were similar for both examinations
- There were significant differences between FEES and videofluoroscopy pharyngeal residue severity scores (\(P < 0.001\))
- FEES residue scores were consistently higher than videofluoroscopy residue scores.

Residue Detection
(Kelly, 2006)

- Pharyngeal residue ratings consistently greater from FEES than from videofluoroscopy
- These findings have significant clinical implications
- Further research is required to examine the impact of FEES and videofluoroscopy examinations on treatment decisions

Efficiency/ Number of Swallows (cont.)

- Number of swallows
  - Establish a baseline for performance
  - Can be used to compare performance after intervention or spontaneous recovery.

- Attempt to quantify and monitor fatigue during mealtime in myasthenia gravis patients
- Patients were given up to 30 consecutive pieces of bread (3cmx3cmx0.5 cm)
- If > 50% of bolus is retained the procedure was stopped
- The number of successfully swallowed bread pieces at that point (1 to 30) quantified the degree of fatigable swallowing


- Case series
  - Subjects: Four severely affected patients with dysphagia as their leading symptom were examined
  - Monitored for normalization or improvement of swallowing function shortly after Tensilon administration
- Results
  - Three/four FEES-Tensilon Test positive for MG-related dysphagia.
  - FEES-Tensilon Test was useful in the differentiation between myasthenic and cholinergic crisis and in guiding treatment decisions.
  - Conclusion The FEES-Tensilon Test is a suitable tool in the diagnosis and therapy of myasthenia gravis with pharyngeal muscles weakness.

Interventions

- Manipulation of bolus viscosity
- Changes in means of delivery/use of devices
- Application of postural changes
- Application of behavioral maneuvers
Direct Interventions (Risk reduction)

- Presentation of food
- Positioning
- Maneuvers
- Diet Modifications

Head Rotation

- Utilized in individuals with unilateral pharyngeal weakness
  - Logemann, Kahrilas, Kobara, & Vakil, 1989; Logemann et al., 1994
  - Closes off the weaker side of the pharynx
  - Enhance the opening of the upper esophageal sphincter with a resultant decrease in pharyngeal retention.

Head Rotation

- Pre-swallow segment observations:
  - Changes to the configuration of the pharynx
  - Changes in bolus flow
- Post-swallow segment observations:
  - discern the presence or absence of residuals in the pharynx
  - make an inference as to whether the desired effect was achieved by implementing this position.
Super-Supraglottic Maneuver

- Designed to improve glottal closure to prevent aspiration before, during and after the swallow
  - Ohmae et al., 1996
    - Provides additional airway protection by using a breath hold with increased effort.

Super-Supraglottic Maneuver

- Pre-swallow segment observations:
  - The clinician will be able to visualize the effect of the maneuver during both the pre-swallow and post-swallow segments.
  - During “white-out” events of aspiration will not be well visualized due to tissue apposition with the objective lens at the height of the swallow.

Super-Supraglottic Maneuver

- Post-swallow segment observations:
  - discern the presence or absence of aspirant in the subglottis
  - make an inference as to whether the desired effect was achieved by implementing this maneuver.
Super Supraglottic Maneuver

- Designed to minimize aspiration by producing volitional airway protection before, during and after the swallow (Ohmae et al. 1996).
- Instruction:
  - Tightly hold breath before the swallow
  - Bear down
  - Continue to hold their breath into the swallow
  - Cough at the completion of the swallow.

Videotaped Examples

- Key Visualization
  - Tight laryngeal valving into the swallow
- Key Measurement
  - Reduction of Duration of Stage Transition
    - No tracheal penetration
  - Secondary UES dysfunction
    - Reduction in residuals in distal pharynx