Accuracy of Dysphagia Assessment

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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 intrajudge reliability.
• **Good Reliability**
  – Oral motor function
  – Vocal quality
  – Visual indication of oral stasis
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 Medicare 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.
"One of the symptoms of an approaching nervous breakdown is the belief that one's work is terribly important."

Bertrand Russell (1872-1970)
My Terribly Important Work

• $A^2$ VAMC QA Program
  – Internal calibration of Videofluoroscopic Evaluations
  – Surprisingly low reliability
# Reliability and Accuracy

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

• Finding the “right” answers!
• Expert panel review
• Expert panel consensus sessions
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 (Rosenbeck 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)
  – Pathophysicsiology
    • What caused delay, asp/pen, etc.
  – Functional Level
    • ASHA NOMs Scale
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>
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<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>
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<tr>
<td>17</td>
<td>&lt;50%</td>
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### Expert Panel Responses With High Concordance

<table>
<thead>
<tr>
<th>Agreement</th>
<th>Stimulus Item</th>
<th>Targeted Finding</th>
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<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>
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</table>
## Expert Panel Responses With Low Concordance

<table>
<thead>
<tr>
<th>Agreement</th>
<th>Stimulus Item</th>
<th>Finding</th>
</tr>
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<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>
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</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
<table>
<thead>
<tr>
<th>Percent in Agreement</th>
<th>Stimulus Item</th>
<th>Finding</th>
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<tbody>
<tr>
<td>81.0% (94/116)</td>
<td>Anatomy</td>
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<td>71.6% (83/116)</td>
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Large Group Responses With Low Concordance

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<th>Percent</th>
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<th>Finding</th>
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<td>33.6% (39/116)</td>
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<td>25.9% (30/116)</td>
<td>Path of Aspiration</td>
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<tr>
<td>25.0% (29/116)</td>
<td>Most Striking Feature</td>
<td>Abnormal</td>
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### Correlation in Pilot Data

**Table 1. Correlations between Demographics and Total Score**

<table>
<thead>
<tr>
<th></th>
<th>Fluoroscopies/Week</th>
<th>Practice Pattern</th>
<th>Total Score</th>
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<tr>
<td>Fluoroscopies/week</td>
<td>Pearson 1.000</td>
<td>-.100</td>
<td>.233</td>
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<td></td>
<td>Correlation</td>
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<td></td>
<td>Sig. (2-tailed)</td>
<td>.293</td>
<td>.012</td>
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<td></td>
<td>N 116</td>
<td>113</td>
<td>116</td>
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<tr>
<td>Practice Pattern</td>
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<td>Correlation</td>
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<td></td>
<td>Sig. (2-tailed)</td>
<td>.293</td>
<td>.926</td>
</tr>
<tr>
<td></td>
<td>N 113</td>
<td>113</td>
<td>113</td>
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<tr>
<td>Total Score</td>
<td>Pearson .233</td>
<td>-.009</td>
<td>1.000</td>
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<tr>
<td></td>
<td>Correlation</td>
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<td></td>
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<td>*.012</td>
<td>.926</td>
</tr>
<tr>
<td></td>
<td>N 116</td>
<td>113</td>
<td>116</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
Newcastle Data Collection 10-2001

- Collected data from practicing UK clinicians
  - Individual responses
  - Automated group response
  - Slow motion individual/group response
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>
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<td>Real time</td>
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<td>6</td>
<td>.2858</td>
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<td>Slow motion</td>
<td>8.0</td>
<td>6</td>
<td>.6039</td>
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Dublin
Reliability of Real Time vs. Slow Motion Viewing High and Low Frequency Groups

<table>
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<th>Group</th>
<th># Cases</th>
<th>#Items</th>
<th>ICC</th>
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</thead>
<tbody>
<tr>
<td>Real low frequency</td>
<td>4.0</td>
<td>6</td>
<td>.0000</td>
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<tr>
<td>Slow low frequency</td>
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<tr>
<td>Real high frequency</td>
<td>4.0</td>
<td>6</td>
<td>.2870</td>
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<tr>
<td>Slow high frequency</td>
<td>2.0</td>
<td>6</td>
<td>.8327</td>
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ASHA 2005  
Reliability of Real Time vs. Slow Motion  

<table>
<thead>
<tr>
<th>Measure</th>
<th>Realtime</th>
<th>Slow</th>
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<tr>
<td>Tongue base retraction</td>
<td>.587</td>
<td>.510</td>
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<tr>
<td>Timing of swallow onset</td>
<td>.511</td>
<td>.730</td>
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<td>Laryngeal Elevation</td>
<td>.577</td>
<td>.744</td>
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<tr>
<td>Pharyngeal Contractions</td>
<td>.186</td>
<td>.759</td>
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</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
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
Means for Real-time vs. Slow Motion

- Real Time
  - High Frequency: 7.50
  - Mid Frequency: 7.00
  - Low Frequency: 6.50

- Slow Motion
  - Grouping Mean Total Score (Accuracy)
  - High Frequency: 8.00
  - Mid Frequency: 7.50
  - Low Frequency: 7.00

Tape Format

Graph shows the comparison of mean total scores for accuracy between real-time and slow-motion tape formats for different frequency groupings.
Discussion: Hypothesis #1

• More practiced clinicians routinely outperformed less practiced clinicians in both slow motion and real time review
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)
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, Cotton & Perry, 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
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

[Normal vf.mov]
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
Lexicon and the Latent Swallow

– Delayed swallow reflex
  • (Lazarus & Logemann 1986; Veis & Logemann, 1985)

– Delayed pharyngeal response
  • (Robbins & Levine, 1988)

– Pharyngeal delay
  • (Langmore et al. 1998; Lazarus, Logemann, Rademaker, Kahrilas, Pajak, Lazar, & Halper, 1993).

– 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.

• Conventional measures
  – 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).
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

• Dua et al. (1997) Coordination of Deglutitive Glottal Function and Pharyngeal Bolus Transit During Normal Eating, *Gastroenterology*;112:73-83

• **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>

- 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

• 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
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.
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
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
Hyalolaryngeal 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.
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
Objective Measures of Hyoloaryngeal Elevation

• 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
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
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 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 Contraction

• The pharyngeal constrictors are comprised of three obliquely positioned muscles that are stacked and layered from the mandible to the cervical esophagus.

• Superior (craniopharyngeus)
• Middle (hyopharyngeus)
• Inferior (thyropharyngeus)
  – 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.
  – AP projection
    • Medial movement of the pharyngeal walls can be visualized
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)
Pharyngeal Contraction Function

• 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 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.
### 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>
</tbody>
</table>
# 8-Point Penetration-Aspiration Scale

<table>
<thead>
<tr>
<th>Score</th>
<th>Description of Events</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Material enters the airway, contacts the vocal folds, and is <strong>not</strong> 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, <strong>and is not ejected from the trachea despite effort</strong></td>
</tr>
<tr>
<td>8</td>
<td>Material enters the airway, passes below the vocal folds, and <strong>no effort is made to eject</strong></td>
</tr>
</tbody>
</table>