Radiation Safety 101

Heather Shaw Bonilha, Ph.D., CCC-SLP
Disclosures

• Funding from NIH/NIDDK (R01 DK098222), “Impact of Pulse Rate on Swallowing Impairment Assessment and Radiation Exposure”

• Salary from faculty appointment at the Medical University of South Carolina

• Speaker Honorarium, NWIF, Inc.
Overview

• Radiation in General
  • Radiation in MBSSs
  • SLP Occupational Radiation Exposure
  • Pulse Rate
Ongoing important topic for SLPs

• ASHA perspectives 2004
  • Steele & Murray; Lemen; Hasselkus, Kander & Sullivan; Arvedson; Kelchner

• ASHA guidelines 2004
  • Guidelines for Speech-Language Pathologists Performing Videofluoroscopic Swallowing Studies
References for radiation in MBSSs

Radiation in General
Radiation: What is it?

Approximate Scale of Wavelength

Radiation type

Copyright permission: ESA-AOES Medialab
Radiation: How is it measured?

<table>
<thead>
<tr>
<th>Exposure</th>
<th>Absorbed Dose</th>
<th>Dose Equivalent/Effective Dose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Common Units</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>roentgen</td>
<td>rad</td>
<td>rem</td>
</tr>
<tr>
<td><strong>SI Units</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coulomb/kilogram (C/kg)</td>
<td>gray (GY)</td>
<td>sievert (Sv)</td>
</tr>
</tbody>
</table>
Radiation: Why does it matter?
Average U.S. Radiation Doses and Sources
Radiation in MBSS
Radiation in MBSS
Radiation from MBSSs: in perspective

- Whole Body CT: 10 mSv
- Average U.S. Annual Dose: 6.2 mSv
- U.S. Avg. Natural Background Dose: 3.1 mSv
- Adult MBSS: 0.2 - 1.27 mSv
- Annual Public Dose Limit (NRC): 1 mSv
- Pediatric MBSS: 0.08 - 0.8 mSv
- From your Body: 0.4 mSv
- Cosmic Rays: 0.3 mSv
- Chest X-Ray: 0.1 mSv
- Trans-Atlantic Flight: 0.025 mSv

50 mSv = Annual Nuclear Worker Dose Limit (NRC)

- Dose Limit from NRC licensed activity
- Radiation Dose
- MBSS Radiation Dose

Graph modified from www.nrc.gov
X-ray Meets Matter

Permission granted from Rod Nave, HyperPhysics Project http://hyperphysics.phy-astr.gsu.edu
Radiosensitive Organs
Radiation & Age
ALARA

• As Low As Reasonably Achievable

• What is reasonably achievable?
SLP & Radiation
Regulations for SLPs conducting MBSSs

• Legal regulations for occupational exposure to x-ray

• 50mSv
Regulations for SLPs conducting MBSSs
Research on SLPs: Hayes et al. 2009

- Average radiation dose for SLPs during MBSSs (not shielded): 0.0015 mGy

- $50\text{mSv} / 0.0015\text{mGy} = 33,333 \text{ MBSSs}$

- $520 \text{ MBSSs (0.0015mGy)} = 0.78 \text{ mSv}$
Research on SLPs: Hayes et al. 2009

• Some MBSS exams showed a significant higher radiation exposure for the SLP

• Why?

• Advice
3 Main Ways to Reduce Radiation
Main Ways to Reduce Radiation

- Clear instructions to patient before beam on
- Efficient, standardized protocol
- Systematically apply strategies
Main Ways to reduce Radiation

• Inverse square law

• 45 degrees from image intensifier (Mahesh et al. 2003)

• Stay out of beam!
Main Ways to reduce Radiation
Pregnancy

• Declaration of pregnancy

• Wear additional pregnancy dosimeter at waist level (under apron)

• 5mSv to the fetus during 9 months

• Can continue working as long as fetal dose within limits
Pregnancy

• No detectable radiation exposure under apron

• American College of Obstetricians and Gynecologists supports the recommendation from the National Council on Radiation Protection and Measurements
Pulse Rate
Continuous vs. Pulsed

Continuous Fluoroscopy

- X-ray tube ramps to appropriate output
- Total Dose (area under curve)

Pulsed Fluoroscopy

- X-ray tube turns on/off at a rapid rate
- Total Dose (area under curve) is greatly reduced

Rate of switching on/off is measured in Frames Per Second (FPS) or Pulses Per Second (PPS)

Used with permission from OthroScan Inc.
# Pulse Rate vs. Frame Rate

<table>
<thead>
<tr>
<th>Pulse Rate</th>
<th>Frame Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 pps</td>
<td>30 frames per second</td>
</tr>
<tr>
<td>15 pps</td>
<td></td>
</tr>
<tr>
<td>7.5 pps</td>
<td></td>
</tr>
<tr>
<td>4 pps</td>
<td></td>
</tr>
</tbody>
</table>
Rationale for Thinking About Pulse Rate

• pulse rate          radiation exposure

• pulse rate          the information we have to assess swallow physiology
Can we use pulsed fluoroscopy to decrease the radiation dose during video fluoroscopic feeding studies in children?

In 7/10 children, the full-depth of penetration was visualized in only 1 frame.
Bonilha et al. 2013

• Pilot Study 1:
  • Compared 30 pps vs 15 pps
  • Swallowing physiology, diet, strategies and prognosis

• Pilot Study 2:
  • Compared 30, 15, 7.5 & 4 pps
  • PAS
Knowledge is Power

• Understand how your fluoroscopy unit works

• Know the settings the radiologists/radiologic technologists use

• Communicate with your radiologists/radiologic technologists about what you need
Acknowledgments
References (1)


References (2)


References (3)


What is the Evidence for Estimating Severity and Outcomes?

Meet the Masters 13th Annual Symposium
November 19, 2014 | Orlando, Florida

Bonnie Martin-Harris, Ph.D., CCC-SLP, BCS-S
Medical University of South Carolina, Professor
College of Medicine, Department of Otolaryngology-Head and Neck Surgery
College of Health Professions
College of Dental Medicine

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- Jordan Hazelwood, M.Ed., CCC-SLP, BCS-S
- Julie Blair, M.S., CCC-SLP, BCS-S
- Kent Armeson, M.S.

Disclosures

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    - NIH/NIDCD R21, Respiratory Phase Training in Head and Neck Cancer, 2009-2012
    - VA RR&D, Respiratory Phase Training in Dysphagic Veterans with Oropharyngeal Cancer, 2010-2012
    - NIH/NIDCD K23, Standardization of Swallowing Assessment, 2003-2009
    - NIH/NIDCD R03, Respiratory and Laryngeal Dynamics During Swallow, 2000-2003
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  - Non-financial

- Non-financial

Functional Domains of Swallowing Impairment

1. Lip Closure
2. Tongue Control
3. Bolus Preparation/Mastication
4. Bolus Transport/Lingual Motion
5. Oral Residue
6. Initiation of Pharyngeal Response
7. Soft Palate Elevation
8. Laryngeal Elevation
9. Anterior Hyoid Excursion
10. Epiglottic Movement
11. Laryngeal Vestibular Closure
12. Pharyngeal Shifting Wave
13. Pharyngeal Contraction
14. Pharyngoesophageal Segment Opening
15. Tongue Base Retraction
16. Pharyngeal Residue
17. Esophageal Clearance
Physiologic Components of Deglutition

Component 9 – Anterior hyoid excursion

Anterior Hyoid Excursion

Facilitates maximal laryngeal closure and pharyngoesophageal segment opening (PES,UES)

Physiologic Components of Deglutition

Laryngeal Elevation Facilitated by Pharyngeal Shortening
### MBSImP™© Component

<table>
<thead>
<tr>
<th>Component 1-Lip Closure</th>
<th>Pre-</th>
<th>Post-</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.4</td>
<td>8.5</td>
<td>0.14</td>
<td></td>
</tr>
<tr>
<td>Component 4-Soft Palate Elevation</td>
<td>5.8</td>
<td>8.4</td>
<td>0.27</td>
</tr>
<tr>
<td>Component 5-Oral Residue</td>
<td>76.4</td>
<td>75.3</td>
<td>0.75</td>
</tr>
<tr>
<td>Component 6-Initiation of Pharyngeal Swallow</td>
<td>90.1</td>
<td>90.4</td>
<td>0.90</td>
</tr>
<tr>
<td>Component 7-Soft Palate Elevation</td>
<td>5.8</td>
<td>8.4</td>
<td>0.27</td>
</tr>
<tr>
<td>Component 8-Laryngeal Elevation</td>
<td>75.8</td>
<td>69.4</td>
<td>0.41</td>
</tr>
<tr>
<td>Component 9-Anterior Hyoid Excursion</td>
<td>94.5</td>
<td>90.0</td>
<td>0.09</td>
</tr>
<tr>
<td>Component 10-Epiglottic Movement</td>
<td>71.0</td>
<td>66.7</td>
<td>0.24</td>
</tr>
<tr>
<td>Component 11-Laryngeal Vestibular Closure</td>
<td>77.4</td>
<td>71.3</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Component 12-Pharyngeal Stripping Wave</td>
<td>57.9</td>
<td>66.1</td>
<td>0.32</td>
</tr>
<tr>
<td>Component 13-PES Opening</td>
<td>80.0</td>
<td>79.6</td>
<td>0.96</td>
</tr>
<tr>
<td>Component 14-Tongue Base Retraction</td>
<td>95.9</td>
<td>88.0</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Component 15-Pharyngeal Residue</td>
<td>95.9</td>
<td>87.8</td>
<td>0.01</td>
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### ASHA NOMS

<table>
<thead>
<tr>
<th>ASHA NOMS</th>
<th>Impairment Limitation Restriction</th>
<th>CMS G-Code Modifier</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>0% impaired, limited or restricted</td>
<td>CH</td>
</tr>
<tr>
<td>6</td>
<td>1-20% impaired, limited or restricted</td>
<td>CI</td>
</tr>
<tr>
<td>5</td>
<td>20-40% impaired, limited or restricted</td>
<td>CJ</td>
</tr>
<tr>
<td>4</td>
<td>40-60% impaired, limited or restricted</td>
<td>CK</td>
</tr>
<tr>
<td>3</td>
<td>60-80% impaired, limited or restricted</td>
<td>CL</td>
</tr>
<tr>
<td>2</td>
<td>80-100% impaired, limited or restricted</td>
<td>CM</td>
</tr>
<tr>
<td>1</td>
<td>100% impaired, limited or restricted</td>
<td>CN</td>
</tr>
</tbody>
</table>

### Dysphagia Severity “Classes”

- **Functional**
- **Mild**
- **Moderate**
- **Severe/Profound**

### Purpose

- Identify presence and classify severity of dysphagia severity
  - MBSimP™© components
  - Oral/Pharyngeal totals
  - Original scale
  - Scaled totals
  - Total scores summed component scores
  - Weighted scaled totals
  - PAS
    - Maximum
    - Mean
    - Median
Subjects

<table>
<thead>
<tr>
<th>Class</th>
<th>N</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Functional</td>
<td>98</td>
<td>44%</td>
</tr>
<tr>
<td>Mild</td>
<td>43</td>
<td>19%</td>
</tr>
<tr>
<td>Moderate</td>
<td>45</td>
<td>20%</td>
</tr>
<tr>
<td>Severe/Profound</td>
<td>39</td>
<td>17%</td>
</tr>
<tr>
<td>TOTAL</td>
<td>225</td>
<td>100%</td>
</tr>
</tbody>
</table>

Four “Class” Dysphagia

- Using weight scaled components, predicting the severity of dysphagia using statistical model with the combination of the following independent variables:
  - Scaled oral components
  - Scaled pharyngeal components
  - Max PAS
  - “Class” is based on highest probability for each patient

Proportional Odds Model

<table>
<thead>
<tr>
<th>True Class</th>
<th>Functional</th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Functional</td>
<td>92</td>
<td>0</td>
<td>3</td>
<td>3</td>
<td>98</td>
</tr>
<tr>
<td>Mild</td>
<td>30</td>
<td>0</td>
<td>10</td>
<td>3</td>
<td>43</td>
</tr>
<tr>
<td>Moderate</td>
<td>17</td>
<td>0</td>
<td>16</td>
<td>12</td>
<td>45</td>
</tr>
<tr>
<td>Severe</td>
<td>13</td>
<td>0</td>
<td>11</td>
<td>15</td>
<td>39</td>
</tr>
</tbody>
</table>
Two “Class” Dysphagia

- Used logistic regression to predict two “classes” dysphagia severity
- Independent variables same as in proportional odds model for four “classes” of dysphagia severity
Bonnie Martin-Harris, Ph.D., CCC-SLP, BCS-S

**Covariate (x) = scaled oral and pharyngeal components + scaled maximum PAS**

<table>
<thead>
<tr>
<th>Component</th>
<th>Coefficient</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lip closure</td>
<td>2.830</td>
<td>0.0542</td>
</tr>
<tr>
<td>Tongue control during bolus hold</td>
<td>-1.605</td>
<td>0.0624</td>
</tr>
<tr>
<td>Water preparatory measures</td>
<td>-1.241</td>
<td>0.1029</td>
</tr>
<tr>
<td>Initial bolus volume</td>
<td>1.091</td>
<td>0.0877</td>
</tr>
<tr>
<td>Velopharyngeal overlap</td>
<td>-2.226</td>
<td>0.1366</td>
</tr>
<tr>
<td>Resistance of pharyngeal opening</td>
<td>1.470</td>
<td>0.0459</td>
</tr>
<tr>
<td>Soft palate relaxation</td>
<td>1.306</td>
<td>0.4044</td>
</tr>
<tr>
<td>Laryngeal elevation</td>
<td>-0.671</td>
<td>0.4936</td>
</tr>
<tr>
<td>Epiglottis elevation/occlusion</td>
<td>2.450</td>
<td>0.0001</td>
</tr>
<tr>
<td>Lingual movements</td>
<td>-0.421</td>
<td>0.0451</td>
</tr>
<tr>
<td>Laryngeal vestibular closure</td>
<td>0.668</td>
<td>0.1956</td>
</tr>
<tr>
<td>Pharyngeal stripping wave</td>
<td>-0.257</td>
<td>0.6181</td>
</tr>
<tr>
<td>Pharyngeal/epiglottic excursion</td>
<td>-0.677</td>
<td>0.4689</td>
</tr>
<tr>
<td>Tongue base retraction</td>
<td>-1.236</td>
<td>0.2178</td>
</tr>
<tr>
<td>Pharyngeal residue</td>
<td>1.542</td>
<td>0.3459</td>
</tr>
<tr>
<td>MBSImP™© PAS (maximum)</td>
<td>1.002</td>
<td>0.0487</td>
</tr>
</tbody>
</table>

Next Steps

- Rather than predict pre-defined “classes” of severity, use latent class models to **discover “classes” of dysphagia described by scaled oral & pharyngeal MBSImP™© scores, and PAS**
- Latent classes describe categories of dysphagia that are predicted by MBSImP™© and PAS scores
- May have some overlap with the severity classes previously described, but may also identify uniquely defining dysphagia phenotypes associated with combinations of MBSImP™© scores and PAS

Clinical Data/ Patient Oriented Outcomes

- Dysphagia Handicap Index (DHI)
- Eating Assessment Tool (EAT-10)
- Functional Oral Intake Scale (FOIS)
- M.D. Anderson Dysphagia Inventory (MDADI)
- Diet Grade
- Feeding Status
See Course Handout for References & Suggested Readings
What is the Evidence for Estimating Severity and Outcomes?
Bonnie Martin-Harris, Ph.D. CCC-SLP, BCS-S
Meet the Masters 2014 | Orlando, FL | References & Suggested Readings


What is the Evidence for Estimating Severity and Outcomes?

Bonnie Martin-Harris, Ph.D. CCC-SLP, BCS-S

Meet the Masters 2014 | Orlando, FL | References & Suggested Readings


41. Satterfield, L. Policy Analysis: Making Sense of G-Codes, PQRS and Other Alphabet SoupNew Medicare outcomes reporting requirements can be confusing and complicated. Here are some FAQs to help get you started. 2013. ASHA Leader. 18(3);16.


44. Swigert N. Patient Outcomes, NOMS, and Goal Writing for Pediatrics and Adults. SIG 13 Perspectives on Swallowing and Swallowing Disorders (Dysphagia), April 2014, Vol. 23, 65-71. doi:10.1044/sasd23.2.65

Estimating Severity and Outcomes: Comparisons to a normal reference perspective

Catriona M. Steele
PhD, S-LP(C), CCC-SLP, BCS-S, Reg. CASLPO, ASHA Fellow

www.SteeleSwallowingLab.ca

Disclosure

• NIDCD grant exploring sensory motor interactions in swallowing related to viscosity
• Stimuli provided for my research by Flavour Creations, Nestle Health Science, Bracco Canada Inc.
• Conference speaker for sessions sponsored by industry partners (Nestlé Nutrition Institute, Bracco, Campbells, Nutricia)
• No personal financial interests in any barium, thickeners or thickened products

Why do a videofluoroscopy?

✓ To provide evidence to support differential diagnosis
✓ To evaluate anatomy for structural anomalies
✓ To identify aspiration (and patient response)
✓ To identify post-swallow residue
✓ To observe and describe the physiology of the oropharyngeal swallow and determine why aspiration or residue are occurring
✓ To determine the suitability of specific interventions
✓ To evaluate treatment outcomes

VFSS is NOT simply a tool for aspiration detection.

To confirm a hypothesis about WHY a functional outcome like aspiration or residue is happening, we need TWO things:

– A normal reference perspective
– A standard way of determining whether the patient tests within normal limits
Robbins, 2007

- Post-swallow barium contrast residue was judged from the videofluoroscopic image when the hyoid bone returned to rest, operationally defining the end of the swallow.
- Measurements were taken in the oral cavity, valleculae, posterior pharyngeal wall, pyriform sinus, and upper esophageal sphincter.
- Ratings were scaled on a 3-point system:
  - 0 corresponded to no barium residue
  - 1 = a coating of barium residue (a line of barium on a structure)
  - 2 = an area larger than a line of barium on a structure.

Research Updates to Share

- New method to measure residue severity
  - Proposed boundary defining “too much” residue
- Normative references for hyoid excursion
  - Scaling to correct for differences in neck length
  - 2-point distance vs. position measures

Acknowledgment

Dr. Sonja Molfenter
sm16@nyu.edu

1. Rating Residue Severity

0 – no residue
1 – “mild” i.e., 0-25% full (versus height of the space)
2 – “moderate”, i.e., 25-50% full
3 – “severe”, i.e., > 50% full

The Normalized Residue Ratio Scale (NRRS) (Pearson, Molfenter, Smith & Steele, 2012)

- Calculated using ImageJ analysis software
- Measures residue area in pixels and area of the space in pixels (valleculae or pyriform sinuses)
- Adjusts for differences in size using a cervical spine scalar

\[
NRRS = \frac{A1}{A1+A2} \times \left(\frac{A1}{N^2}\right) \times 10
\]

Acknowledged issues with the NRRS

- Vulnerable to variation based on frame selection
- Particularly true for measurement of spatial housing
- Unclear yet what values have clinical relevance
  - > 0.06 for NRRSv associated with risk of aspiration on a clearance swallow (Molfenter & Steele, 2013)
- New data suggest there is a significant relationship between degree of pharyngeal constriction and resulting NRRS scores (both valleculae and pyriform)

2. Hyoid Excursion:

What is normal?

Molfenter & Steele, 2011
Hyoid Excursion:

What is normal?

Molfenter & Steele, 2011

Maximum Hyoid Excursion

• What do you need to measure this:
  1. Find the frame of maximum excursion
     • i.e., the frame when the hyoid reaches the furthest forward position at maximum elevation
  2. Use the length of the C2-4 spine as a reference
  3. Determine whether hyoid distance from C4 is $\geq$ 1.5 times the length of the C2-4 spine scalar
     • IF yes, within normal limits ✓
     • IF no, hyoid excursion is reduced ✗

References


Penetration and aspiration:
Determining the source and probing immediate treatment effects in the fluoro suite

Ianessa A. Humbert, Ph.D.
Emily Plowman, Ph.D.
Kate Hutcheson, Ph.D.

Meet the Masters Symposium
November 19, 2014
American Speech Language Hearing Association Annual Convention

Importance of determining the primary contributing source of penetration or aspiration

Ianessa A. Humbert, Ph.D. CCC-SLP
Assistant Professor
Swallowing Neurophysiology Laboratory
Department of Physical Medicine and Rehabilitation
Johns Hopkins School of Medicine

Disclosures
1. National Institutes of Health
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   National Center for Medical Rehabilitation Research
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2. National Institute of Deafness and Other Communication Disorders
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   Grant number: 14BGIA20380348

3. ASHFoundation
   Clinical Research Grant

Our Goal
Provide practical examples of how using valuable time in the fluoro suite might determine the trajectory of intervention
Why?

Example:
What if the SLP model of swallowing rehab was applied to physical therapy?

Problem: High risk of falling when transitioning between bed and wheelchair.

- **Pre-treat eval**
  - View kinematics to determine problem, severity

- **Treatment**
  - Provide treatment in another room, while listening for signs and symptoms of falling
  - Make treatment plans based on kinematics

- **Post-treat eval**
  - Review kinematics to determine treatment effects
  - Adjust treatment and mobility recommendations

The kinematic assessment periods in the SLP model of swallowing treatment are critical!
Importance of testing baseline outcome of treatments on the source of penetration or aspiration

Expectations for treatment trajectories in various populations

Disease is the primary driver of patient progress

Fluoros are snapshots throughout

Despite the limitations, we rely on these brief time points to decode swallowing pathophysiology
Stroke

2 patients
Same PA score
Different PA source

Major contributor?
Delayed swallow onset

Normal Range:

Molfenter et al 2012
Derived from 14 studies

Chin down evidence based?

Theory: Increased vallecular space provides “holding bay” until swallow onset (Logemann, 1998)

Delay unchanged in research (Bulow et al 2001; Shanahan et al 1993).

Valleculae size unchanged in research (Welch et al 1993)

Other options

Tap into the spontaneous laryngeal valving

Avoid a forward posture during swallowing

Train bolus hold and intentional swallow onset

Each might be enhanced with visual biofeedback in fluoro suite. USE THE ADVANTAGE!
Major contributor?
UES opening duration

Highly responsive to bolus volume

Molfenter et al 2012
Derived from 14 studies

Larger bolus evidence based?

Molfenter et al (2014)

“Within the UES opening duration data, it is interesting to note that every study in which two or more bolus volumes were compared demonstrated a systematic volume effect: an increase in volume resulted in a corresponding increase in mean UES opening duration”

SUMMARY

Videofluoroscopy is meant to tell us what the patient can and cannot do.

Try to test as many clinical swallowing exam correlates as possible.

Establish a baseline for boluses with and without a strategy, then re-test the same trials during follow-up.
Applications of Videofluoroscopy in Neurodegenerative Disease

Emily K. Plowman, Ph.D., CCC-SLP
Lauren C. Tabor, M.S, CCC-SLP
Communication Sciences & Disorders
Neurology
Jay McCann Culverhouse Center for Swallowing Disorders
University of South Florida

Neurodegenerative Disease: Special Considerations
- Nature of Degeneration: Rapid vs. Gradual
- Online adjustments & Patient awareness
- Cognitive involvement (FTD)
- High incidence of Aspiration
- Probe immediate impact of specific maneuvers, compensations & dietary modifications
- Evaluate impact of active interventions across time
- Important to track natural change / deterioration over time

Importance of Tracking Swallow Function Over Time

Are All Aspiration Events the Same?

Pre-EMST

Post-EMST

PAS: 1
FOIS: 7
EAT -10: 8/40

PAS: 6
FOIS: 3
EAT -10: 30/40

PAS: 8
FOIS: 2
EAT -10: 38/40
**Not All Aspiration Events are the Same!**

**When:** Before vs. During vs. After

**Why:** Premature spillage vs. Glottic closure vs. Residue

**Response:** Effective cough vs Ineffective cough vs Absent

*The MBS Exam Will Provide This Information For You! This will Guide your Treatment Targets*

---

**Response Profiles in ALS**

---

**Not all 7’s are Created Equal…**

**CONSIDER THE SOURCE**

Identify When and Why to Guide Your Next Move!

---

**VFSS: Using Your Time Wisely**

**CASE STUDIES**
Case Study 1

1. Identify the Problem
2. Trial Compensations

Impact of Trialed Strategies During VFSS:

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<tr>
<td>Head Turn (L/R)</td>
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Case Study 2

1. Identify the Problem
2. Trial Compensations

Impact of Trialed Strategies in VFSS:

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</table>
Applications of Videofluoroscopy in Head & Neck Cancer

Kate A. Hutcheson, PhD, CCC-SLP, BCS-S
University of Texas MD Anderson Cancer Center
Department of Head & Neck Surgery
Dysphagia after HNC...
Post-surgical dysphagia

Location

Approach

Closure
Radiation-Associated Dysphagia

Acute (edema)

Chronic (fibrosis)

Late (denervation)

↓ mobility

Hutcheson et al, Cancer (2012)
HNC-associated dysphagia

Mechanics
- Laryngeal closure
- Bolus push
- Esophageal opening

Structure
- Edema
- Defect
- Stricture

- Aspiration
- Residue
Sensory

- Silent aspiration
- Discordant self-report
  - Under-reporting (late)
  - Over-reporting (early)
“Penetration during the swallow, aspiration after”

Penetration-aspiration scale = 8
Case 1
Case 2
Trajectories of Dysphagia after HNC

- Surgery
- Radiation (90%)
- Radiation (10%)

Swallowing function

Pre | Initial | Recovery | Late
---|---|---|---
Normal | Impaired | Normal | Impaired

71% of patients experience dysphagia after HNC.
### Monitoring change over time

<table>
<thead>
<tr>
<th>Pre-treatment</th>
<th>2 years</th>
<th>8 years</th>
</tr>
</thead>
</table>

![Images of different time points](image)

*Time points: Pre-treatment, 2 years, 8 years.*
Videofluoroscopic Observations as Biomarkers of Disease and Conditions in Infants and Children

Meet the Masters 13th Annual Symposium
November 19, 2014

Maureen A. Lefton-Greif, PhD, CCC-SLP, BCS-S
Associate Professor, Depts. of Pediatrics, OHNS, PM+R
The Eudowood Division of Pediatric Respiratory Sciences
Johns Hopkins University School of Medicine

Financial
- NIH/NIDCD, R01. Standardization of videofluoroscopic swallow studies for bottle-fed children
- Ataxia-Telangiectasia Children’s Project
- Speaker Honorarium, NWIF, Inc

Non-Financial
- None

All Diagnoses: Sick New Born Infants Discharged from Short Stay Hospitals

Diagnosis of Feeding Problems (779.3) in Infants Discharged from Short Stay Hospitals

Maureen A. Lefton-Greif, PhD, CCC-SLP, BCS-S

National Hospital Discharge Survey; CDC 12/20/13
Prevalence of Swallowing Problems in Children (3 - 17 years)

- Def: swallowing problem: >1 wk / past 12 mos
- 569 ± 63 thousand children
- 0.9% ± 0.1% of children overall
- Onset: $\bar{x} = 8.2 \pm 0.4$ years
- $\frac{\text{♀}}{\text{♂}}: 45.6 \pm 5.3$ vs $54.4\% \pm 5.3\%; \ P = 0.558$
- 13.4% ± 1.6% given Dx for swallowing problem

House-hold based self-reported health status in 2012

---

**dysphagia** (dɪs-ˈfæ jē-ˈä)

[G. dys, difficult + G. phagein, to eat]

“Dysphagia is **not** a disease. Rather it is a **symptom** of a disease that may be affecting any part of the swallowing tract from the mouth to the stomach.”

Donner, 1986

---

Swallowing Dysfunction

- Potential Impact
  - Aspiration / Resp. Compromise
  - Nutrition Compromise
  - Alter family/social interactions

Early identification and prompt initiation of interventions may improve health, development, and quality of life by lessening impact of the dysphagia.
Swallowing Dysfunction: As a symptom ...

Dysphagia

• Aspiration / Resp. Compromise
• Nutrition Comprise
• Alter family/social interactions

Specific swallowing impairments and their severity may serve as biomarkers of disease / disease progression or responses during clinical trials

State of the Art in Pediatrics

Normal Infant Swallow

Image of normal infant swallow does not ...

• Show typical range of swallowing patterns
• Show impact of variation on health-related outcomes
• Rule-out “micro” aspiration
Dysphagia with Aspiration

Image of aspiration but does not tell:
- Reasons for aspiration
- Whether aspiration is consistent with history or presentations
- Presence of related swallowing impairments
  - Likelihood of other aspiration events
  - Whether or what child can eat/drink safely
- Whether swallowing supports attainment of nutritional goals
- Anything about the prognosis

Multiple Factors Determine the Impact of Dysfunctional Swallowing

Host Characteristics
- Diagnostic condition(s)
- Co-morbidities
- Severity of dysphagia

Age / Timing of Exposure
- Growth and development
- Susceptibility to injury

Environmental / Social Factors
- Feeding techniques
- Health care access and management
- Exposure to environmental stressors

Adapted: Lefton-Greif + McGrath-Morrow 2007

Standardization of the Acquisition and Reading of VFSS Images is Essential for ...
- Objective characterization and tracking of the natural history of swallowing impairments
- Providing outcome measures for interventions in dysphagia
- Identifying phenotypes of swallowing impairments for children with diagnostic conditions associated with dysphagia
Standardization of the Acquisition and Reading of VFSS Images May ...

- Decrease variability in exchange of patient information
- Reduce x-ray exposure to children, a population exquisitely sensitive to the affects of ionizing radiation

Standardization of VFSS in Bottle-Fed Children

Used MBSImP as proof of concept to develop a Pediatric Tool to capture swallowing features unique to the bottle-fed child

Developed 24 Component Pediatric Tool from...

- Literature review
- Clinical experience
- Expert consensus for inclusion of salient items
- Expert review and multiple scoring revisions

• Developed and tested in adults
• Captured oropharyngeal swallowing impairment in adults
• Reliably scored; reliability dependent on training!
Development of Pediatric Tool: Where are we?

- Completing reliability training
- Accrued >300 subjects
- VFSS exams will be rated by trained 7 SLPs at Hopkins and MUSC

Tool for Bottle-Fed Children: Oral–Pharyngeal Transit Domain

Component 7- Bolus Location at Initiation of Pharyngeal Swallow

0 = Above or at valleculae
1 = Bet. valleculae + pyriform sinuses
2 = In pyriform sinuses
3 = No initiation

Tool for Bottle-Fed Children: Initiation of Pharyngeal Swallow

0 = Above or at valleculae
1 = Bet. valleculae + pyriform sinuses
2 = In pyriform sinuses
3 = No initiation
Aim 3: Compare physiologic impairment scores between thin and thick liquids

Preliminary Data: We retrospectively reviewed and used the tool to score VFSS images obtained from 25 consecutive examinations of bottle-fed children who were imaged drinking thin (Varibar apple juice®) and nectar (Varibar®) contrasts.

Preliminary Data: Differences in impairment scores between thin & thick liquid contrasts
- 25 exams were reviewed and scored
- 15 male:10 female
- mean age = 0.54 mos.
- 11 (44%) VFSS’s during in-patient admissions

<table>
<thead>
<tr>
<th>Domain</th>
<th>Selected Components</th>
<th>Consistency Related Differences in Impairment (No. of pts.)</th>
<th>Lower impairment scores* (No. of pts.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oral</td>
<td>No. of sucks to form bolus</td>
<td>2 0 0</td>
<td>Thin 2 Thick 0</td>
</tr>
<tr>
<td>Oral</td>
<td>Oral residue after each suck/swallow burst</td>
<td>4 2 2</td>
<td>Thin 2 Thick 2</td>
</tr>
</tbody>
</table>

* Lower score = better function

Multiple Factors Determine the Impact of Dysfunctional Swallowing

Host Characteristics
- Diagnostic condition(s)
- Co-morbidities
- Severity of dysphagia

Age / Timing of Exposure
- Growth and development
- Susceptibility to injury

Environmental / Social Factors
- Feeding techniques
- Health care access and management
- Exposure to environmental stressors

Adapted: Lefton-Greif + McGrath-Morrow 2007
Standardization of Videofluoroscopic Swallow Studies in Bottle-Fed Children, Thanks to….  

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Julie Blair, MS  
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Jeanne G. Hill, MD  
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Michelle M. Macias, MD  
Katlyn McGrattan, PhD  
John Sandidge, MA  
David R. White, MD

**Selected References**

Bhattacharyya N. The prevalence of pediatric voice and swallowing problems in the United States. The Laryngoscope 2014; n/a.


National Hospital Discharge Survey, CDC Accessed: 11/09/14  
Features of VFA in Infants

- Suck & Oral Transit Time
- Pharyngeal Transit Time
- Number of Sucks per Swallow
- Tongue Movement
- Collection
- Nasopharyngeal Reflux
- Material in the Supraglottic Space
- Residue in the Pharynx
- Hesitation in the Cervical Esophagus

Newman et al., 1991
Features of VFA in Infants

- Sucks per Swallow
  - A measure of jaw excursion per pharyngeal swallow

- Suck & Oral Transit Time
  - Begin with mandible in upward excursion towards the nipple and end on last frame material in the valleculae before it was propelled into pyriform sinuses

- Pharyngeal Transit Time
  - Begin on first frame where material appeared to thrust into the pyriform sinuses and end when material reached cervical esophagus

Newman et al., 1991

Features of VFA in Infants

- Collection of fluid before initiation of transit
  - Forced choice paradigm in terms of anatomic location from an anterior to posterior position

- Tongue Movement
  - Forced choice paradigm of five possibilities (Stripping)

- Nasopharyngeal Backflow (9.5%)

Newman et al., 1991

Features of VFA in Infants

- Material in Supraglottic Space (0)

- Residue in the Pharynx (61.9%)
  - Material remaining after completion of the swallow in valleculae and pyriform sinuses

- Hesitation in the Cervical Esophagus (62%)
  - Determination defined as a lack of movement of the barium suspension seen on two consecutive frames

Newman et al., 1991

Reliability of Features of VFA in Infants

- High reliability between two raters (ICC)
- Excellent reliability for suck and oral transit
- Acceptable reliability for pharyngeal transit time measures

Videofluoroscopy provides a reliable means for analyzing the infant swallow

Newman et al., 1991
A New Research Question

- What are the physiologic differences between swallows of thin liquid barium and swallows of nectar thickened barium in infants with diagnoses affecting their respiratory functioning?

From previous research...

- From the Newman analysis:
  - Number of sucks per swallow
  - Suck time
  - Oral transit time
  - Collection of bolus before the swallow
  - Pharyngeal transit time
  - Nasopharyngeal Backflow
  - Residue

New Measures for VFA in Infants

- Novel Measures
  - Initiation of velar movement
  - Duration of cricopharyngeal opening
  - Duration of pharyngeal constriction
  - Time to laryngeal closure
  - Duration of laryngeal closure
  - Bolus position at initiation of laryngeal closure
  - Epiglottic tilting
  - Pen-Asp Scale

New Measures for VFA in Infants

<table>
<thead>
<tr>
<th>Measure</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>Duration of cricopharyngeal opening</td>
<td>Begin with first frame of bolus head in the cricopharyngeal sphincter and end with first frame where cricopharyngeus is closed. The difference between these two measures was the duration of cricopharyngeal opening.</td>
</tr>
<tr>
<td>Duration of pharyngeal constriction</td>
<td>Begin with first frame of maximum pharyngeal constriction and end with onset of pharyngeal relaxation at the velum. The difference between these two measures was the duration of pharyngeal constriction.</td>
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</table>
**New Measures for VFA in Infants**

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<td>Time to laryngeal closure</td>
<td>Begin with first frame at initiation of laryngeal closure with upward movement of the arytenoids and end with first frame of complete laryngeal closure. The difference between these two measures was the time to laryngeal closure.</td>
</tr>
<tr>
<td>Duration of laryngeal closure</td>
<td>Begin with first frame of complete laryngeal closure and with first frame showing initiation of laryngeal opening. The difference between these two measures was the duration of laryngeal closure.</td>
</tr>
</tbody>
</table>

**Reliability of New VFA Measures**

- **Pearson’s r** for # sucks/swallow, suck time, oral transit time, initiation of velar movement, pharyngeal transit time, duration of CP opening, duration of pharyngeal constriction, time to laryngeal closure, duration of laryngeal closure, & score on PAS.
- **Spearman’s rho** for bolus location at BOT propulsion, bolus location at initiation of laryngeal closure, presence of residue after the swallow, & location of residue after the swallow.
- Crosstab measures for % Agreement for epiglottic tilt and presence of NPB b/c of insufficient variability.
Reliability of New VFA Measures

Percent Agreement
- 100% agreement for intra & inter rater reliability
  - Absence of epiglottic tilt
  - Absence of NPB

Reliability of New VFA Measures

Inter rater reliability for the continuous variables
$r = 0.829$ to $r = 1.00$
(Pharyngeal Transit Time to Initiation of Velar Movement)

Intra rater reliability for the continuous variables
Analyst 1: $r = 0.847$ to $r = 1.00$
(Oral Transit Time to Initiation of Velar Movement)
Analyst 2: $r = 0.894$ to $r = 1.00$
(Duration of Laryngeal Closure to Initiation of Velar Movement)

Reliability of New VFA Measures

Inter rater reliability for noncontinuous variables
$rs = 0.783$ to $rs = 1.00$
(Bolus Location at Initiation of Laryngeal Closure to Bolus Location at Base of Tongue Propulsion)

Intra rater reliability for noncontinuous variables
Analyst 1: $rs = 0.753$ to $rs = 1.00$
(Presence of Residue after the Swallow to Bolus Location at Base of Tongue Propulsion)
Analyst 2: $rs = 0.755$ to $rs = 1.00$
(Presence of Residue after the Swallow to Bolus Location at Base of Tongue Propulsion)

Conclusions
Oral and pharyngeal measures all found to reach acceptable levels of reliability

- Which of these measures matters clinically?
- How do these and other measures relate to outcomes in infants and children?
References

- Gosa, MM. (2012). Videofluoroscopic analysis to determine the effects of thickened liquids on oropharyngeal swallowing function in infants with respiratory compromise. Communication Sciences & Disorders, The University of Memphis: Memphis, TN.