INSTRUMENTAL ASSESSMENTS OF SWALLOWING

Goals / Questions Identified During Clinical Evaluation.... Instrumental Evaluation??????
- Need? Goals/questions can be answered only with...
- Direct visualization of structures not seen on clinic evaluation for diagnostic or management information
- Which one? Determined on basis of….
  - Host characteristics - phases of swallowing?
  - Ability and willingness of child to cooperate?

Instrumental Evaluation??????
- When? Timing for when info would be most helpful
- …and if needed, how to increase likelihood of cooperation and reduce risks associated with exam

Four Phases of Swallowing
- Oral preparatory
- Oral
- Pharyngeal
- Esophageal

Dysphagia (dis-fā’ jē-ā) [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

Routes of Airway Contamination
- Direct from above due to swallowing problem
- Indirect from below due to regurgitation, reflux
- Direct + indirect
- Communication between airway & GI tract (e.g., laryngeal cleft or TEF)
Instrumental Assessment Procedures

- Upper Gastrointestinal Examination (UGI)

49 patients (age: \( \bar{x} = 4.7 \), range: 0.4–30.3 mos)
- Only 21 (43%) with documentation of whether swallowing was imaged on UGI
- All children with aspiration on UGI (3 fps) had thin liquid aspiration on VFSS; however, 53% without aspiration on UGI aspirated on VFSS.
- UGI findings are specific but not sensitive markers for aspiration on VFSS.
- UGI imaging of swallows had an appreciable increase on radiation exposure.

Instrumental Swallowing Evaluation Procedures for Oropharyngeal Function

- Flexible Endoscopic Evaluation of Swallowing (FEES)

Potential Candidates for FEES: Children who …

- Are NPO or taking too little to participate in VFSS
- Have structural or suspected structural abnormalities
- Have abnormal VFSS + question re: airway / respiratory interaction
- Need repeated exams
White-out

Aspiration of Saliva on FEES

Instrumental Swallowing Evaluation Procedures for Oropharyngeal Function

- Flexible Endoscopic Evaluation of Swallowing (FEES)
- Videofluoroscopic Swallow Study (VFSS)

PAST - Barium Swallow (1965)

Brief History: Radiologic Evaluation of Swallowing

- Early 1900’s: upper aerodigestive tract
- 1930’s: Fluoroscopy discovered to capture the rapid and dynamic movements during swallowing on barium swallow or UGI
- 1980’s: UGI modified to focus on the oropharyngeal structures

Shoe-fitting Fluoroscopes: 1920’s-1960’s

Hess Shoe Store – Baltimore, MD

Langmore, 2001
Modified Barium Swallow Study (MBS) or Videofluoroscopic Swallow Study (VFSS)

The MBS is designed to assess not only whether the patient is aspirating, but also the reason for the aspiration, so appropriate treatment can be initiated.

Logemann, 1983

VFSS is a Tool to...
- Evaluate biomechanical and physiologic function and dysfunction
- Determine swallowing safety
- ID effects of compensatory strategies and maneuvers on swallowing
- Determine appropriate diet

VFSS is a Tool That Enables...
- Visualization of bolus flow in relation to structural movements through oral & pharyngeal phases in real time
- Screening of esophageal transit, basic motility
- ID of aspiration and if so, salient factors
- When in sequence & relation to swallow function
- Texture specificity
- Estimate of risk
- Response to aspiration
- Interpretations of findings relative to physiology

VFSS is a Tool that ....
- Provides information that may enhance safety & efficiency of swallowing or delineate reasons for NOT advancing oral feeding
  - Bolus & positioning variables
  - Oral feeding strategies
  - Therapeutic maneuvers (older children)

VFSS does NOT....
- Rule out aspiration
- Determine if child aspirates while feeding (important finding but not reason for exam)
- Simulate a real meal
- Evaluate oral skills for bolus formation
- Evaluate chewing skills
- Esophageal function (only upper esophagus)

VFSS Does NOT....
- Define feeding & swallowing development
- Determine the impact of the swallowing problem on a specific child (& family)
- Predict the progression of the feeding / swallowing problem or timing of its resolution
VFSS: Known Limitations
- Involves radiation
- Samples or provides a brief view of frequent and repetitive function

VFSS Procedure is a Process that Includes....
- Decisions to carry out exam
- Planning
- Carrying it out
- Reading/Reviewing Findings
- Interpreting Findings
- Management decisions re: “whole” child
- Documenting

Follow Same Steps for All VFSS’s
- Decision to carry out exam – yes or no

VFSS: Indications
- Suspected oropharyngeal dysphagia
- Diagnostic or management needs which would be clarified by VFSS findings
- Patient is ready, willing, and able to participate
- Findings may make a difference

Potential Candidates for VFSS Examination
- Risk for aspiration by history or observation
- Prior aspiration pneumonia
- Suspicion of pharyngeal/laryngeal problem on basis of underlying condition/presentations
- Need to define oral, pharyngeal, & upper esophageal components for management

“Ready, Willing, & Able”
- Medical stability
- Cardiopulmonary stability
- Nutrition stability (may be exceptions)
- Surgical stability
- Baseline level following surgery
- Alertness, maturity, & organization or state
- Ability to tolerate “bolus” feeds (may be exceptions)
"Ready, Willing, & Able"

- Signs of swallowing, even if limited to saliva & “tastes” of food or liquid
- Signs of interest in oral feeding or increasing oral feeding, if safe to do so
- For infants, non-nutritive suck (NNS)

NNS is a pre-requisite (necessary but not sufficient) to successful nipple feeding

Preparation of Tube Feeder: NPO

- Child should demonstrate some level of oral intake, at least for therapeutic “taste trials”
- NG tube - remove in most instances
- Amount per bolus: 2 to 3 cc (1 cc = saliva swallow)
- Less than 10-15 cc., need to question validity & reliability
- Medication schedules maintained or in some cases, adjusted as needed

VFSS: Indications

- Suspected oropharyngeal dysphagia
- Diagnostic or management needs which would be clarified by VFSS findings
- Patient is ready, willing, and able to participate

Findings Make a Difference

- Benefits > Risks associated with radiation
- Determined by defining which questions can be answered by completing a VFSS

….And VFSS’s have associated risks/burdens …. 

- Financial costs
- Radiation exposure

.DAM Principle

Don’t Order Tests that Don’t Affect Management

(Huda, 2012)
Radiologic Considerations

- Is a VFSS needed?
- Determining and identifying which questions may be answered by completing a VFSS
- If so, do the benefits outweigh the risks
- Radiation concerns
  - Getting the necessary information at the lowest “cost” to the patient

Follow Same Steps for All VFSS’s

- Decision to carry out exam – yes or no
- Planning

ALARA: As Low as Reasonably Achievable

Practice mandate adhering to the principle of keeping radiation dose to patients and personnel as low as possible.

Radiologic Mandate: As Low as Reasonably Achievable (ALARA)

- Adhering to the principle of keeping radiation dose to patients and personnel as low as possible
- 3 Major principles
  1. Time – individual and repeat exams
  2. Distance – doubling distance between your body and the radiation source divides radiation exposure by a factor of 4
  3. Shielding

Radiation Concerns in Children

Young children are particularly sensitive to the effects of ionizing radiation
- Inherently greater radiosensitivity than adults since they have a higher proportion of dividing cells
- More remaining years of life for development of radiation-induced cancers

General: Radiation Safety Considerations

- Focus exam to address specific questions
- Keep exams short AND infrequent
  - Limit “fluoro” time
  - Not “every 3 months”!
- Use careful collimation
  - Try to avoid orbits of eyes
- Use appropriate shielding - all in radiology suite
Factors that Influence Radiation Exposure

- Duration of individual VFSS exam
- Number of VFSS exams
- Magnification and frame rate
- Host characteristics - my opinion
  - Cooperation
  - Oropharyngeal factors
  - Multidisciplinary interaction (e.g., with SLP)
  - Operator’s training / techniques

Factors that Influence Radiation Exposure

- Duration of individual VFSS exam
- Number of VFSS exams

Keep in mind: children with complex health & developmental issues may have many radiology studies throughout their lifetimes.
- Think about how many VFSS’s the child in front of you may need

Factors that Influence Radiation Exposure

- Duration of individual VFSS exam
- Number of VFSS exams
- Magnification and frame rate

Duration of Radiation Exposure During VFSS

<table>
<thead>
<tr>
<th>Source of Information</th>
<th>Population</th>
<th>Duration (Mins)</th>
<th>Mean</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weir, et al.¹</td>
<td>90 children</td>
<td>2.47 ± 0.81</td>
<td>0.08 to 4.60</td>
<td></td>
</tr>
<tr>
<td>Unpublished²</td>
<td>25 bottle-fed children</td>
<td>1.21</td>
<td>0.29 - 2.15</td>
<td></td>
</tr>
</tbody>
</table>

¹ Strauss & Kaste, 2006
² Unpublished 2009

Indications for Repeat VFSS

- Same as for initial VFSS
- Information needed for
  - Definition of etiology or diagnosis
  - Guide for management decisions
- NOT some arbitrary time interval – there needs to be some reason or “change”
- Child should be at baseline (e.g., not ill)

Child-Specific: Radiation Safety Considerations

Remember that incomplete or poor evaluation is a waste of x-ray exposure

- Use continuous (30 fps) not pulse fluoroscopy (<30 fps)¹
- Failure to detect supraglottic penetration & aspiration, especially on liquids has been documented in children
- Use magnification, if needed

¹ Cohen, 2008
10 children (1-33 mos): liquid swallows
Recorded at 30 fps
Counted # frames where penetration was visible

Impact of Frame Rate – Cohen (2009)
- 70% w/full penetration on 1 frame (30% missed)
- Additional frames w/partial penetration ranged (0-2)
Conc: 15 fps is inadequate for judging presence and extent of penetration (residual barium) in children

Child-Specific: Radiation Safety Considerations
Remember that incomplete or poor evaluation is a waste of x-ray exposure
- Use continuous not pulse fluoroscopy\(^1\)
  - Failure to detect supraglottic penetration and aspiration, especially on liquids swallows, has been documented in children
- Use magnification, if needed

VFSS Procedure: Planning
- Preparation: Caregivers & children
  - Oral vs. non-oral feeders (tastes at least)
  - Medications (keep regular administration)
- Physical set-up
  - Radiologic considerations
  - Seating & positioning (typical / optimal)
  - Shielding
  - Coning- avoid orbits of eyes – cannot eliminate the thyroid gland

Planning: Preparation & Involvement of Caregivers, Children, & Health Care Providers
- Oral vs. non-oral feeders (tastes at least)
- Contrast preparation / flavoring
- Utensil selection
- Order of liquid & food presentations
- Develop plans with health care providers in advance of VFSS, as necessary

Planning: Preparation & Involvement of Caregivers, Children, & Health Care Providers
- Ask caregivers to bring food samples + utensils
- Textures & barium recipes need to be standardized
- Data lacking, especially in children
- Poor relationship between viscosity of dysphagia diet foods & swallow barium test feeds of different viscosities\(^1\)

\(^1\) Cohen, 2009

\(^1\) Stroed et al., 2008
Follow Same Steps for All VFSS's
- Decision to carry out exam – yes or no
- Planning
- Carrying it out

Child-Specific: Radiation Safety Considerations
- Position to allow fluoro tube to move with patient if possible
- Use information from clinic or bedside evaluation
- Incorporate neurodevelopmental information

Carrying It Out: Nasogastric (NG) / Nasoduodenal (ND) Tube
- **NG**
  - Remove if possible – OK from attending service, nursing, or caregivers
  - Remove if causing or contributing to dysphagia
- **ND**
  - Leave in place

Carrying It Out: Lateral View
- **Encompassing**
  - Lips anterior
  - Soft palate superior
  - Posterior pharyngeal wall posterior
  - Fifth to seventh cervical vertebrae inferior, varying with age of child
- **Simultaneous view of oral, pharyngeal & upper esophagus before food is presented**
- **Pulse fluoro at this time**
Carrying It Out: PA View
- When asymmetry is known or suspected
- Unilateral vocal fold paralysis or paresis
- Tonsil related questions
- Other possibilities?
  - Keep in mind radiation exposure time
  - Importance of findings for management

Carrying It Out
- No fixed order for presentations in pediatrics
- Preferable to start with thinnest liquid
  - May use controlled bolus size to start (e.g., syringe or spoon before bottle or cup drinking)
- Work toward thicker as needed
  - To decrease residue in pharynx that may complicate interpretation
- Exceptions: Caregiver tells you that child will not accept anything else if child gets liquid first

General:
Radiation Safety Considerations
- Know when to terminate VFSS
  - Needed information obtained
  - Not likely to get any additional useful information
- "You've got to know when to hold 'em
Know when to fold 'em
Know when to walk away..." 1978

VFSS: Therapeutic Strategies
- Strategies
  - Can be objectively evaluated
  - Proceed from least to most restrictive
  - Dependent on neurodevelopmental status
- In children, may include
  - Modifications in utensils
  - Alterations in sensory-input
  - Modifications in consistency
  - Maneuvers, in older children
VFSS: Screening Esophagus

- Depends upon the questions
- If oropharyngeal function does not explain the signs/symptoms that are of concern

Follow Same Steps for All VFSS’s

- Decision to carry out exam – yes or no
- Planning
- Carrying it out
- Reading images = what you see

Reading Fluoroscopy Images

- Anatomic abnormalities
- Bolus flow
  - Timing – delay or pooling
  - Direction
  - Clearance – residue
  - Airway entry – before, during, or after swallow
- Structural movement - spatial, temporal
- Response to compensatory strategy

Findings: Objective Descriptors Of Bolus Movement

- Primary focus is on pharyngeal phase, but oral & upper esophageal functions interrelate
- Terms that reflect severity in findings, e.g., mild, moderate, severe are interpretations of severity, not findings
- Terms should be meaningful (e.g. not “flash” penetration
- Frequency of a particular finding may be important prognostic indicator

What is the relationship between penetration and aspiration?
What’s known about the pen-asp relationship in children?

- Relationship bet. depth of penetration & aspiration\(^1\)
  - 85% children (N = 125, 7 days -19 yrs) w/ deep laryngeal pen → asp
- Temporal relationship\(^2\)
  - Asp. occurs later than laryngeal pen. on VFSS
    - 1st pen = 50.77 sec
    - 1st asp = 65.41sec.

\(^{1}\)Friedman & Frazier, 2000
\(^{2}\)Newman et al, 2001

**MYTH**

- Swallowing is “safe” because infant had penetration without any obvious aspiration
- Consider:
  - Frame rate
  - Whether a “representative” feeding was imaged
  - Child’s ability to tolerate aspiration

Silent Aspiration

Aspiration without any external behavioral signs such as coughing or choking.

If aspiration is “silent”, why is it a problem?

- Primary airway response to aspiration is absent – lack of airway clearance
- Caregivers keep feeding children because primary “signal” of feeding difficulty is absent

How common is silent aspiration?

<table>
<thead>
<tr>
<th>Population</th>
<th>Age Range (Years)</th>
<th>% pts. with aspiration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Young peds</td>
<td>0 - 5</td>
<td>89 - 100</td>
</tr>
<tr>
<td>Older peds + adults</td>
<td>5 - 55</td>
<td>71 - 94</td>
</tr>
<tr>
<td>Varied</td>
<td>Median 65</td>
<td>51 - 58</td>
</tr>
<tr>
<td>Very old</td>
<td>&gt; 90</td>
<td>73 - 88</td>
</tr>
</tbody>
</table>

**Myth: Aspiration Can Be Ruled Out**

ASK:
- Why? – Why is aspiration/swallowing dysfunction suspected?
- Where? What parts of the system are likely to be involved?
- What? What action will be taken if aspiration is present
- How much? Frequency? Amount?
Aspiration on VFSS Findings

Images of aspiration do not tell:
• The severity of the dysphagia
• Whether aspiration is consistent with a child’s history or clinical presentations
• Presence of related swallowing impairments
• Likelihood of other aspiration events
• Whether or what the child can eat or drink safely

Image of aspiration does not tell:
• Whether swallowing supports attainment of nutritional goals
• Ability of person to tolerate aspiration
• The meaning or significance of aspiration – on future exams or from other institutions
• “If” and “when” a VFSS should be repeated

Current State of Art

• No objective measures for biomarkers of status or change
• No consistency in how examinations are conducted or reported – hinders interpretation and probably contributes to increased x-ray exposure for many children

Videofluoroscopic Swallow Studies

Used to make critical decisions for medically fragile children despite:
• Procedural variability (e.g., contrasts, positioning)
• Variability in imaging rates, duration of exams, and criteria for repetition of evaluations
• Lack of agreed upon:
  • Definitions of physiologic parameters
  • Measures for interpreting and reporting results
• Increased awareness of potential impact of radiation exposure, particularly in children
Standardization of Videofluoroscopic Swallow Studies for Bottle-Fed Children

To develop and test a standardized measurement tool and scoring schema for quantification of swallowing impairments in bottle-fed children

MPIs: Maureen A. Lefton-Greif
Bonnie Martin-Harris

Severity of the Dysphagia

- Phases
- Ability to compensate
- Prognosis dependent upon underlying diagnostic condition
- Standardization

Adapted: Lefton-Greif + McGrath-Morrow 2007

Common Factors that Determine / Modify the Impact & Management of the Swallowing Dysfunction

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

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

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

Goal of this project are to develop and test a standardized measurement tool and scoring schema for quantification of swallowing impairment in bottle-fed children
Standardization of Interpretation of VFSS Images: Why?

- Enable objective characterization and tracking of the natural history of swallowing impairments
- Provide outcome measures for interventions in dysphagia
- Serve as biomarkers for clinical trials for children with diagnostic conditions associated with dysphagia
- Decrease variability in exchange of patient information
- Potentially reduce unnecessary exposure to radiation

Tool for Bottle-Fed Children: Nutritive Sucking/Oral Containment

Number of sucks to form bolus for swallowing

What have we learned?

- Feasibility of reliable judgments of physiologic structures, bolus movements and airway protection captured in VFSS images obtained from bottle-fed children
- Training with precise definitions improves the reliability of identification and quantification of these judgments even in experienced clinicians
- Some components are more difficult to distinguish than others

Most Challenging Components

- Localized to functional domains:
  - Nutritive Sucking / Oral Containment and Transport
  - Airway protection
- Plausible explanations
  - Differing resolution of viewing screens – real world
  - Difficulty detecting very small amounts of barium
  - Incomplete calcification of structures that delimit the oropharyngeal anatomy in young children

Clinical Implications

- Experience with either adult or pediatric VFSS exams
  - May not translate into reliable readings of VFSS exams with bottle-fed children
- Training and standardization of procedures and operational definitions are essential for:
  - Planning and carrying out studies
  - Reporting information for salient clinical outcomes (to be defined)
  - Potentially limiting x-ray exposure
Standardization of Videofluoroscopic Swallow Studies in Bottle-Fed Children, Thanks to….

**Johns Hopkins**
- Kathryn A. Carson, ScM
- Renee Flax-Goldenberg, MD
- Jeanne Pinto, BS, MA
- Jenny Wright, BS

**MUSC**
- Bonnie Martin-Harris, PhD.
- Jeanne G. Hill, MD
- Kate Humpheries, MS, CCC-SLP
- Katlyn McGrattan, PhD, CCC-SLP

Special thanks to our raters

**Johns Hopkins/Maryland**
- M. Cara Erskine, MEd, CCC-SLP-A
- Jeannine Hoch, MA, CCC-SLP
- Sandra B. Martin, MS, CCC-SLP

**MUSC**
- Heather McGee, MA, CCC-SLP
- Katlyn McGrattan, PhD, CCC-SLP
- Keeley McKelvey, MA, CCC-SLP
- Melissa Montiel, MA, CCC-SLP