The Diagnosis and Management of Infant Dysphagia

2nd Annual Meeting
The Contemporary Management of Aerodigestive Disease in Children
Vanderbilt University, Nashville, TN
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Nationwide Children’s
When your child needs a hospital, everything matters.”
Objectives

1. Prevalence, Types, Symptoms and Risk Factors for Infant Dysphagia

2. Physiology, Maturation and Regulation of Infant Dysphagia

3. Pathobiology and Approaches to Diagnosis and Therapies for Neonatal and Infant Swallowing Problems
1. Prevalence, Types, Symptoms and Risk Factors for Neonatal Dysphagia
Prevalence of Swallowing Problems

- **26%** premies have feeding problems; **31%** of < 1 yr olds with BPD have airway and digestive concerns
  

- **20- 80%** premies with neurodevelopmental issues have feeding concerns during Infancy
  
  Field et al. J Paediatr Child Health 2003
  Rommel et al. JPGN 2003

- **3.5%** of all newborns had feeding problems, **3-fold** more if born < 37 wks, and **7-fold** more if born VLBW
  
  Motion et al. Ambulatory Child Health 2001

- Infants < **28 wks GA** have significant oral feeding delays as well as prolonged LOS vs. infants > 28 wks GA; Majority of healthy premies achieved oral feeding skills by **36-38 wks PMA**
  
  Jadcherla et al. J Perinatol 2009
Types of Neonatal Swallowing: Normal and Abnormal

- **Oral Phase**
  - Preparatory
  - Extraction
  - Lingual-Palatal Coordination
  - Airway Protection

- **Pharyngeal Phase**
  - Propulsion
  - Airway Protection

- **Esophageal Phase**
  - Peristalsis
  - Airway Protection

- **Oromotor Inertia & Oral Pooling**
- **Delayed initiation of Pharyngeal Phase**
- **Cardio-Respiratory Events**
- **Penetration, Aspiration & Airway Symptoms**
- **GERD**
- **Oral Aversion**
### Symptoms and Signs of Neonatal Swallowing Problems

#### Oral-Pharyngeal Phase
- Latching problems
- Delay suck
- Lack of rhythm
- Lack of Lingual movement
- Poor extraction
- Lingual-Palatal dys-Coordination
- Naso-pharyngeal regurgitation
- Delayed initiation of Pharyngeal swallow
- Silent aspiration
- Peristaltic failure
- Gagging, arching and irritability

#### Pharyngeal-Esophageal Phase
- Pharyngeal pooling
- Wet gurgly breathing
- Cough with feeds
- Stridor
- Nasopharyngeal regurgitation
- Delayed Pharyngeal Phase
- Pharyngo-upper esophageal sphincter dys-coordination
- Laryngeal penetration
- Laryngeal aspiration
- Apnea, Bradycardia and Desaturations
- Cardio-Respiratory Events

Overt or Silent Anterograde Aspiration and Airway /Lung disease
GERD and Retrograde Aspiration and Airway /Lung disease
Oral Aversion and behavioral feeding problems
Risk Factors of Neonatal Swallowing Problems

**Maternal Illness**
- Poly / Oligo Hydramnios
- Prescribed or Non-prescribed Drugs
- Diabetes
- Hypertension

**Provider Related**
- Maturational
- Breast Feeding related
- Feeding Program
- NICU-ITIS
- NICU-PHOBIA

**Fetal Birth Defects**
- Congenital Anomalies: Orofacial, ENT, Airway, Esophageal & GI, Neurological and Cardiac
- Metabolic Defects
- Genetic Syndromes
- Premature Birth

**Neonatal Illness**
- Infections
- Neurological Lesions & HIE
- Drug Addiction
- Chronic Lung Disease
- Growth Failure
- Surgical Neonate
2. Physiology, Maturation and Regulation of Neonatal Swallowing
Vagal Neural pathways regulate the functions of Big Brain and Little Brain

- Esophagus and airways share similar innervation by the Vagus
- Afferent and efferent neuronal pathways modulate sensory-motor function


Mittal RK et al. NEGM
Oromotor activity during perinatal development

• Non nutritive sucking promoting physiological stability (Pinelli)

• Sensory-motor oral stimulation and early oral feeding (Rocha)

• Some oromotor interventions may enhance feeding and swallowing (Arvedson)

• Early oral stimulation accelerates transition from tube to oral feeding (Lau)

• N-trainer therapy provides entrainment of neural pathways with better oro-rhythms (Barlow)

• Coordination of swallowing, respiration and glottal reflexes undergoes adaptation during maturation (Jadcherla)

Rhythmic alternation of suction and expression
In a 8-day-old full-term infant

rhythmicity

Courtesy: Lau, C 2000
Upper Gut: Oromotor Skills

Test: Non-Nutritive Suck Evaluation

How: Evaluate pressure waveform patterns from a pacifier attached to a pressure transducer inserted into infant's mouth

Courtesy: Barlow 2012
Automated Impedance Manometry Analysis

- Used to correlate esophageal motility pressure and impedance plots

- Pressure and flow variables can be derived and related to bolus residue to predict pharyngeal dysfunction and aspiration

- Swallow Risk Index
  - Derived from bolus timing, pressure, contractile vigor, and bolus presence

*Omari and Rommel et al. Am J Gastroenterol (2011)*
Postnatal maturation advances mechanisms of esophageal propulsion

Ability to observe differences between smooth and striated muscle functions. Infants exhibit two distinct types of peristalsis that changes with maturation. Neuromotor mechanisms of esophageal propulsion develop with further maturation.

Gupta A, Jadcherla SR. Am J Gastroenterology 2009)
Responses to Esophageal Provocation are modified with stimulus and maturation

Secondary Peristalsis is 5.2 times more likely to occur at older maturation vs Primary peristalsis at younger maturation

Esophageal stimuli evoke responses dependent on stimulus volume and physicochemical properties and are modified across maturation.
Responses to Pharyngeal Provocation are modified with stimulus and maturation

Pharyngeal Reflexive Swallowing is the predominant neonatal response to pharyngeal stimulation (vs. Pharyngo-upper esophageal contractile reflex). Occurs more frequently with liquid stimulation (vs. air) and advances across maturation.

Table 1: Stimulus-Volume Pharyngeal Reflexive Swallow Recruitment Across Maturation

<table>
<thead>
<tr>
<th>% PRS Response</th>
<th>Media</th>
<th>0.1 mL</th>
<th>0.3 mL</th>
<th>0.5 mL</th>
<th>P-Value for Volume Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time 1</td>
<td>Air</td>
<td>22.6</td>
<td>34.8</td>
<td>22.2</td>
<td>0.9</td>
</tr>
<tr>
<td>Water*</td>
<td>25.0</td>
<td>66.7</td>
<td>100.0</td>
<td>&lt;0.0001</td>
<td></td>
</tr>
<tr>
<td>Time 2</td>
<td>Air</td>
<td>32.4</td>
<td>33.3</td>
<td>40.6</td>
<td>0.5</td>
</tr>
<tr>
<td>Water†</td>
<td>44.4</td>
<td>72.7</td>
<td>93.3</td>
<td>0.002</td>
<td></td>
</tr>
</tbody>
</table>

*P<0.0001 vs air; †P=0.02 vs air. Water stimuli evoke more PRS responses (vs air) at time-1 and time-2. Additionally, water evokes more PRS responses with increasing volumes.

Jadcherla et al. Ped Res. 2014
Oral Feeding Challenge Test

**Px-Inf.**

- **Slow Flow, 142/26/100**
- **Regular Respir**
- **Propagated Swallow**

**M-Eso-Inf.**

- **Medium Flow, 150/44/100**
- **Regular Respir**
- **Propagated Swallow**

**Respiration**

- **Fast Flow**
- **Erratic Respir**
- **Decreased Suck: Swallow Ratio**

**EMG**

**Pharynx**

**UES**

**P-Eso**

**M-Eso**

**D-Eso**

**LES**

**Stomach**

10 S

Jadcherla et al. JPGN 2009
Symptoms during Pharyngeal-Airway Reflex Interactions

Jadcherla et al. Am J Gastroenterology 2009
Swallowing involves integrated function of multiple tissues

1. CONTRACTION & RELAXATION
2. COORDINATION & REGULATION OF MOTILITY BY CNS AND ENS
3. MATURATION & EXPERIENCE
4. AERODIGESTIVE PROTECTIVE REFLEXES

Modified after: Wood J et al
3. Pathobiology and Approaches to Diagnosis and Therapies for Neonatal Swallowing Problems
Types of Aspiration

• Anterograde
  – Pre-deglutitive
  – Intra-deglutitive
  – Post-deglutitive

• Retrograde

• Silent

• Can Aspiration be a normal phenomenon?
Abnormalities during Upper GI or VFSS

- **13.4% (63/472)** full-term infants had swallow dysfunction on UGI
- Incidence of aspiration ranged from **25 to 73%** for infants with swallowing dysfunction

  _Mercado-Deane et al. Pediatr Radiol  2001_

- **85% (n=125)** of children exhibiting deep laryngeal penetration eventually aspirated, and aspiration occurred 15 sec after laryngeal penetration

  _Friedman and Frazier, Dysphagia, 2000_
  _Newman et al, Pediatrics, 2001_

- Video-manometry in 8 dysphagic children (2-28 months) differed from adult swallowing with respect to:
  - Epiglottic movement
  - Tongue driving force
  - Amplitude of pharyngeal contraction
  - UES pressure

- Comparable pharyngeal shortening and pharyngeal wall movement
- Hyoid movement and laryngeal elevation were inconsistently visualized

VFSS as a test of airway protection safety

- **Penetration** - the passage of material into the larynx that does not pass below the vocal folds

- **Aspiration** - the passage of material below the level of the vocal folds

- **Silent Aspiration** - the passage of material below the level of the vocal folds without subsequent coughing, choking, or gagging

Rosenbek et al, *Dysphagia*, 1996
## Penetration-Aspiration Scale

<table>
<thead>
<tr>
<th>Score</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Material does not enter 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>

Rosenbek et al, Dysphagia, 1996
Is Aspiration Normal?

- 45% of normal patients had detectable aspiration during sleep and those sleeping more soundly were at a greater risk
  
  *Huxley et al, AM J Med 1978*

- 50% of Normal subjects aspirate small volumes (0.01-0.2 ml) during sleep
  
  *Gleeson et al, Chest 1997*

- Neurologically normal patients also aspirate- lower rates of OPA 27%-38% with SA similar (71%-97%)
  
  *Weir, KA et al. Chest 2011*

- Amount unknown in neonates and infants
Diagnosis of Swallowing Abnormalities during VFSS

- Neonates (N=20; GA 30.9 ± 4.9) with abnormal VFSS:
  - 30% nasopharyngeal reflux
  - 35% pooling
  - 35% delayed swallow
  - 55% aspiration
  - 90% laryngeal penetration

VFSS parameters were similar between Feeding success vs. Feeding failures

Jadcherla et al. JPGN 2009
ORIGINAL ARTICLE: GASTROENTEROLOGY

Impact of Personalized Feeding Program in 100 NICU Infants: A Novel Pathophysiology-based Approach for Better Outcomes

*Sudarshan R. Jadcherla, †Juan Peng, ‡Rebecca Moore, §Jason Saavedra, ||Edward Shepherd, ††Soledad Fernandez, #Steven H. Erdman, and **Carlo DiLorenzo

J Pediatr Gastroenterol Nutr 2011
"Dr. J-Study: Complex problems need Personalized Multidisciplinary Therapy"

Dysphagia

- Cough or Choking spells
- Frequent Spit ups

Arching

- ALTE
- Irritability
- Failure of medical therapy

Referral to Neonatal Feeding Disorders Program

Individualized Strategy

- Good Clinical Exam with Feeding Challenge
- Anatomical evaluation
- Comprehensive medical evaluation
- Occupational Therapy evaluation
- Dietetic evaluation
- Psychologist advice
- Extended pharyngo-esophageal manometry evaluation during a feeding cycle

Individualized innovative Management care plan

- Personalized guided care plan
- Volume & caloric regulation
- Growth monitoring
- Occupational Therapy
- Hunger manipulation
- Operant Conditioning methods
- Manipulation of gut motility cycles
- Postural Therapy
- Pharmacological treatment

Feeding success

- Compliance
- Follow up
- Review

Feeding failure

Outcomes at discharge

Jadcherla et al. JPGN 2009
Jadcherla et al. JPGN 2011
# Feeding Program Vs. Historical Controls

## Referrals for Gastrostomy

<table>
<thead>
<tr>
<th></th>
<th>Innovative Feeding Program (N=100)</th>
<th>Historical control group (N=50)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Gestation Age (weeks)</td>
<td>31</td>
<td>33</td>
</tr>
<tr>
<td>Mean Birth Weight (kg)</td>
<td>1.8</td>
<td>2.3</td>
</tr>
<tr>
<td>Neuropathology (%)</td>
<td>44</td>
<td>54</td>
</tr>
<tr>
<td>BPD (%)</td>
<td>74</td>
<td>48</td>
</tr>
<tr>
<td>GER symptoms (%)</td>
<td>66</td>
<td>54</td>
</tr>
<tr>
<td>Feeding success at discharge (%)</td>
<td>51</td>
<td>10</td>
</tr>
<tr>
<td>Feeding success at 1st birthday (%) *</td>
<td>84.3 (75/89)</td>
<td>42.9 (21/49)</td>
</tr>
<tr>
<td>Mean Length of stay (wk)</td>
<td>19</td>
<td>18</td>
</tr>
</tbody>
</table>

*In the innovative feeding program, nine patients died after discharge and two patients were transferred to other hospitals; thus data from the remaining 89 patients is shown. In the historical control group, one patient died after discharge; thus data from 49 patients is shown.
Feeding Outcomes: Comparisons between innovative feeding program and historical controls for Gastrostomy Referrals

**Innovative Feeding Program**
- Primary Oral Feeding: 51%
- Tube + Oral feeding: 15%
- No Oral Feeding: 34%

**Historical Controls**
- Primary Oral Feeding: 71%
- Tube + Oral feeding: 14%
- No Oral Feeding: 28%

At Discharge: P<0.0001
At 1 year Birthday: P=0.0004
Savings in health care $$$

Health care costs for children with feeding tubes at discharge =

- $180,000 per infant over 5 yrs, and
- $46,875 for the first year

Piazza et al. 2004

SAVINGS: By avoiding 51 Gastrostomy tubes, we saved:

- $9.1 Million over 5 years
- $2.1 million over the 1st year

Jadcherla et al. JPGN 2011
Summary

1. Prevalence, Types, Symptoms and Risk Factors for Neonatal Swallowing Problems

2. Physiology, Maturation and Regulation of Neonatal Swallowing

3. Pathobiology and Approaches to Diagnosis and Therapies in Neonates with Swallowing difficulties