2013 Charleston Swallowing Conference

Session 12
Cardiopulmonary Disorders In Pediatrics
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Authors:
Lefton-Greif, Halstead, Zyblewski

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Airway & Swallowing Issues in Pediatric Cardiac Disorders

Lucinda Halstead, M.D.¹

Associate Professor, Departments of Otolaryngology-Head & Neck Surgery, & Pediatrics
Medical Director, MUSC Evelyn Trammell Institute for Voice & Swallowing
Medical University of South Carolina, Charleston, SC
halstead@musc.edu

*nothing to declare

Objectives:

- To describe the airway and swallowing issues associated with congenital cardiac disorders and their treatments
- Correlation of airway endoscopy and MBSS
- Discuss medical and surgical management

Learning Outcomes:

- Describe the swallowing impairment in Hypoplastic Left Heart Syndrome
- Describe the swallowing impairment in DiGeorge Syndrome(22q11.2 deletion)
- Describe the relationship of RLN paralysis to dysphagia in congenital cardiac disorders
Introduction:

- Repair of many congenital cardiac anomalies places the recurrent laryngeal nerve (RLN) at risk.
- Will review the repair of several of these conditions and the impact on voice & swallowing.

Congenital Cardiac Disorders

- Patent Ductus Arteriosis (PDA)
- Hypoplastic Left Heart Syndrome (HLH)
- Interrupted Aortic Arch
- Syndromes associated with these disorders exacerbating airway and swallowing issues:
  - DiGeorge Syndrome (22q11.2 deletion)
  - Downs Syndrome (Trisomy 21)

Acquired Cardiac Disorders

- Heart strain/failure from airway obstruction
  - Obesity
  - Laryngomalacia
  - Neurological issues
Normal Larynx

Congenital Cardiac Disorders
- Patent Ductus Arteriosis (PDA)
- Hypoplastic Left Heart Syndrome (HLH)
- Interrupted Aortic Arch
- Syndromes associated with these disorders exacerbating airway and swallowing issues
  - DiGeorge Syndrome (22q11.2 deletion)
  - Downs Syndrome (Trisomy 21)

Risk of left recurrent laryngeal nerve injury during surgery
Congenital Cardiac Disorders

- Patent Ductus Arteriosis (PDA)
  - Risk of left recurrent laryngeal nerve injury during surgery
    - Voice initially breathy
    - Repeated video exams help document injury & recovery
    - Voice improvement – often becomes normal
    - Nerve recovery
    - Compensation by the right vocal fold
    - Persistent poor voice requires surgical management

- Swallowing
  - Occasional abnormal
  - Almost always improves
  - Persistent swallowing problems usually due concurrent medical problems
TVF Paralysis Post PDA & TVF Dyskinesia Secondary To Laryngomalacia

MBS Penetration

LARYNGOMALACIA

Pacing difficulties  Post supraglottoplasty
Congenital Cardiac Disorders
- Interrupted Aortic Arch

Dx Aortic Arch Interruption, L TVF Paralysis, MBSS WNL

Dx Interrupted Aortic Arch, L TVF Paralysis, MBSS WNL
Dx Interrupted Aortic Arch, Normal TVF Mobility, MBSS + Aspiration

Congenital Cardiac Disorders
- Hypoplastic Left Heart Syndrome (HLHS)

dx HLHS, h/o aspiration, TVF glottic gap, MBSS + penetration
dx HLHS, h/o aspiration, TVF glottic gap
MBSS + penetration

Congenital Cardiac Disorders
- Hypoplastic Left Heart Syndrome (HLH)
- Two studies
  - Pilot study evaluating RLN injury & swallowing dysfunction in Hypoplastic Left Heart Syndrome on interstage mortality
  - Pilot study characterizing swallowing deficits of Hypoplastic Left Heart Syndrome infants

Laryngopharyngeal Dysfunction Following the Norwood Procedure
- Margaret L. Skinner, Lucinda A. Halstead
  Catherine S. Rubinstein, Andrew M. Atz
  Diane Andrews, Scott M. Bradley

Medical University of South Carolina
Evelyn Tramell Institute for Voice and Swallowing
Charleston, South Carolina
Study Aims

- Incidence
- Clinical Impact

1. Recurrent laryngeal nerve injury
2. Swallowing Dysfunction

Norwood Procedure

- Improved operative survival
- Other measures of outcome

Study Patients

- April 2003 – December 2004
- 36 Norwood procedures
- 18 Biventricular repairs
  - Aortic arch reconstruction
  - Median sternotomy
Postoperative Studies

1. Fiberoptic Laryngoscopy
2. Modified Barium Swallow (MBS)
   - Norwood 33/36 (92%)
   - Biventricular 17/18 (94%)

Results: Norwood Patients (N = 33)

Laryngoscopy
Left true vocal fold paralysis 3 (9%)

Modified Barium Swallow
Abnormal 16 (48%)
Aspiration 8 (24%)
Laryngeal Pen. 3 (9%)

Vocal Fold Paralysis vs. Aspiration

1

- Vocal fold paralysis and aspiration in 1 pt
Predictors of Dysfunction

Vocal fold paralysis or abnormal swallow

- Age
- Weight
- Genetic abnormality
- CPB time
- Circulatory arrest time
- Duration of intubation

P = NS

Norwood Patients: Discharge Feeds

- Gastrostomy Tube 6/33 (18%)
  - Persistent aspiration 3
  - Poor oral intake 3
- Thickened feeds 2

Abnormal MBS: ICU & Hospital Stay

- ICU
- Hospital

P = 0.05

P < 0.01

MBS
Norwood vs. Biventricular Repair

Time Course of Dysfunction

Vocal Fold Paralysis (N=7)

- Follow-up laryngoscopy 4 (3 months – 1 year)
- Persistent paralysis 3
- Improvement 1

Time Course of Dysfunction

Aspiration (N=14)

- Follow-up swallow 13 (1 week – 1 year)
- Normal 8
- Laryngeal pen. 3
- Trace aspiration 2
Outcomes

Norwood Procedure

- Hospital survival: 32/36 (89%)
- Sudden interstage death: 1/32 (3%)

Biventricular Repair

- Survival: 18/18 (100%)

Summary: Norwood Procedure

- Swallowing dysfunction common
  - Abnormal MBS: 48%
  - Aspiration: 24%
- Recurrent nerve injury: 9%
  - Uncommon cause of swallowing dysfunction

Summary: Norwood Procedure

- Incidence of dysfunction is similar after aortic arch / biventricular repair
- Aspiration improves / resolves over time
- Most vocal fold paralysis is permanent
Inferences

- Routine evaluation of swallowing function
  ➔ Tailoring feeding regimens
  ➔ Gastrostomy tube placement

- May contribute to low hospital and interstage mortality
- Persistent paralysis places patient at risk for future airway compromise

Physiologic Oropharyngeal Swallowing Impairment Following Stage I Palliative Repair for Hypoplastic Left Heart Syndrome

- Katlyn E. McGrattan, MS., CCC-SLP
- Maureen A. Lefton-Greif, Ph.D., CCC-SLP, BRSS-S
- Heather McGhee, MS., CCC-SLP
- Bonnie Martin-Harris, Ph.D., CCC-SLP, BR5-S

Specific Aim 1: Identify oropharyngeal swallowing impairments in infants following S1P.
Functional vs. Impaired Oropharyngeal Swallowing Components During initial VFSS (N=23)

Bolus Location at Initiation of Pharyngeal Swallow

Functional vs. Impaired Oropharyngeal Swallowing Components During initial VFSS (N=23)
Timing of Initiation of Pharyngeal Swallow

Functional vs. Impaired Oropharyngeal Swallowing Components During initial VFSS (N=23)

Pharyngoesophageal Segment Opening
Specific Aim 2: Describe changes in oropharyngeal swallowing impairment between the first and second VFSS.

Change in Swallow Impairment in Infants Referred for Follow-Up VFSS (N=9)
Summary:

- Infants with HLHS demonstrate impairments in oropharyngeal swallow physiology following S1P that contribute to laryngeal penetration and aspiration.
- Improvement in oropharyngeal swallowing function within the initial months following S1P is highly variable.

Support and Disclosures for this study

- NIH/NIDCD R01DC008284 Standardization of Videofluoroscopic Swallow Studies for Bottle-Fed Children, 2010-2015
- NIH/CTR TL1/CA000062 Respiratory Swallow Coordination Across Bolus Flow Rates in Preterm Infants, 2011-2013
  http://www.northernspeech.com/MBSImP
- Mark and Evelyn Tanninsel Voice and Swallowing Trust

Congenital Cardiac Disorders

- DiGeorge Syndrome (22q11.2 deletion)
  - Associated with multiple cardiac disorders
  - Voice usually unaffected
  - Often severe swallowing issues
    - Cricopharyngeal achalasia

Cricopharyngeal Achalasia
Cricopharyngeal Achalasia

- Incidence unknown, but rare
- Etiology
  - Congenital failure of cricopharyngeal relaxation
  - 22q11.2 deletion (DiGeorge Syndrome)
- Treatment
  - Balloon dilation
  - Botulinum Toxin injection
  - Cricopharyngeal myotomy
  - Treatment often complicated aberrant path of right common carotid

Cricopharyngeal Achalasia

Pre-Botox  Post-Botox

Cricopharyngeal Achalasia

Pre-Botox  Post-Botox
Congenital Cardiac Disorders

- Downs Syndrome (Trisomy 21)
  - Large tongue
  - Hypotonia

Conclusions:

- Repair of congenital cardiac disorders place the RLN at risk
- There is not a 1:1 relationship of RLN injury to swallowing dysfunction
- Often other medical conditions closely associated with these disorders impact significantly on the infant's ability to swallow

THANK YOU

halstead@musc.edu
Congenital Heart Disease (CHD)

- #1 birth defect - worldwide
- Frequency: approximately 8 per 1000 births
  - ≈ 40,000 babies in US, annually
- #1 cause of birth defect related deaths
- Leading cause of all infant deaths in US

2 Berrier et al., 2010

Congenital Heart Disease (CHD)

- Thousands of them will not reach their 1st birthday and thousands more die before they reach adulthood.
- 28% all major congenital anomalies consist of heart defects

**CHD: Life Long Disease**

- Currently, an estimated 2,000,000 CHD survivors in the US
- For the 1st time, > 50% of survivors of CHD are adults
- 10% of all CHD cases are first diagnosed in adulthood


**CHD: Economic Impact**

- Cost > $2.2 billion a year for inpatient surgery to repair CHD
- > 50% of all children born with CHD will require at least 1 invasive surgery in their lifetime


**Feeding /Swallowing**

- What is known
  - More infants are surviving
  - Nutritional status is a recognized problem and can impact the timing/success of necessary surgeries
  - Estimated incidence of dysphagia are variable
  - Nonetheless, little is known about the characteristics of swallowing impairments in children with CHD
Feeding Challenges

- Common infants with CHD
- May be due to a variety of congenital and acquired anatomical and physiological barriers including:
  - non-cardiac anomalies
  - genetic syndromes
  - neurologic sequelae
  - cardiac failure
  - tachypnea

Hehir et al, 2011

CHD: Life Long Disease

- Almost one-half of all children and adults with complex CHD have neurological and developmental disabilities
- Frequency of DD is associated with severity of CHD


Frequency of Neurodevelopmental Delays and Severity of CHD

- Low incidence with milder forms
  - atrial septal defect, ventricular septal defect, or isolated semilunar valve disease
- Higher frequency with more complex forms of moderate 2-ventricle CHD
  - coarctation of the aorta, complex semilunar valve disease, atrioventricular septal defect, ventricular septal defect with comorbidities, tetralogy of Fallot, total anomalous pulmonary venous connection

Marino et al., 2012
Frequency of Neurodevelopmental Delays and Severity of CHD

- >50% with severe 2-ventricle or palliated single-ventricle CHD
  - transposition of the great arteries, truncus arteriosus, interrupted aortic arch, tetralogy of Fallot/pulmonary atresia with major aortopulmonary collateral arteries, pulmonary atresia with intact ventricular septum, hypoplastic left heart syndrome, tricuspid atresia

Marino et al., 2012

Neurodevelopment Delays Almost Always Occur when CHD is Associated:

- With genetic disorders or syndromes
  - Down syndrome, 22q11 deletion, Noonan syndrome, Williams syndrome
- and multiple congenital anomalies
  - CHARGE syndrome

Marino et al., 2012

Prevalence of neurodevelopmental impairment in the population with congenital heart disease (CHD).

Marino et al. Circulation 2012;126:1143-1172

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**Persistent Feeding Difficulties: Presentation to Out Patient Clinics**

- 74% with developmental delay
- Likely, increased risk for problems with any or all phases of swallowing
- Likely, increased risk of any problems associated with delays in initiation of oral feeding

1 Burklow et al., 2002

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**Primary Functions of Post-Natal Swallowing**

- Direct food, liquid, & saliva from the mouth to the stomach while keeping airway protected
- Provide enough of the right types of liquids & foods for:
  - adults to stay healthy
  - children to grow and develop
- Feeding – should be enjoyable

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**CHD & Common Factors Associated Feeding / Swallowing Concerns**

- Respiratory Factors
  - ↑ risk of aspiration – tachypnea
  - ↑ risk of nutrition compromise: ↑ calories to compensate for metabolic needs
  - Presumed decreased tolerance of aspiration-induced injury

Jadcherla et al., 2009
**CHD & Common Factors Associated Feeding / Swallowing Concerns**

- **GI / Nutrition**
  - Alterations in gut function - impaired, sluggish, neurologic insults

Jadcherla et al., 2009

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**National Pediatric Cardiology Quality Improvement Collaborative (NPC-QIC)**

“Poor nutrition in children with complex CHD is associated with infection risk and increased hospital stay and mortality following cardiac surgery”

- NPC-QIC is the 1st multicenter quality improvement collaborative within pediatric cardiology developed to improve the outcomes of care for children w/ CHD

Anderson et al 2012

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**CHD & Common Factors Associated Feeding / Swallowing Concerns**

- **GI / Nutrition**
  - Alterations in gut function - impaired, sluggish, neurologic insults
  - Neurologic sequelae
  - Neuroplasticity – impact of learning

Jadcherla et al., 2009
Congenital Heart Disease: What is Known About Feeding Problems and Oropharyngeal Dysphagia?

Aims: To...
- characterize the evolution of feeding milestones in infants with CHD and
- identify variable that impacted the feeding abilities

Study
- Retrospective study: 56 infants
- Classification: Acyanotic vs Cyanotic CHD
Acyanotic = left to right shunt; Cyanotic = right to left shunt

Acyanotic - enough O₂ gets circulated to prevent turning blue
Cyanotic - heart is pumping so poorly that child turns blue due to lack of O₂

http://sketchymedicine.com/2012/07/acyanotic-vs-cyanotic-congenital-heart-defects/

Sept 8, 2013

Study

- Retrospective study: 56 infants
- Classification: Acyanotic vs. Cyanotic CHD
- Excluded: Infants w/ chromosomal syndromes

Jadcherla et al., 2009

Study

- Oromotor readiness: defined as ability to take first oral feed
- Successful oromotor skills: defined as ability to take maximal oral feeds
  - Max feeds were the same whether by gavage or oral feeding
- Endpoints were discharge or death

Jadcherla et al., 2009
Findings

- 93% of all survivors achieved maximal nipple feeds at discharge
- Cyanotic vs. Acyanotic group, had
  - Significant delays in initiation + achieving max gavage feeding
  - Significant delays in initiation + achieving max oral feeding
  - Prolonged length of hospitalization

Jadcherla et al., 2009

Findings:
Feeding Adversely Impacted by...

- Prolonged duration of respiratory support
- Prolonged duration of narcotic & vasopresser support
- Use of by-pass
- Neurologic concerns

Jadcherla et al., 2009

Aim: To describe predictors or oral feeding outcomes after early surgical intervention
Study

- Retrospective study: 56 infants
  - Male (69%)
  - > 35 wks gest (86%)
- Inclusion:
  - Required surgical intervention + survived
  - Heterogeneous group of CHD

Results: Predictors of Oral Feeding Amounts

- Positive Predictors
  - Amount taken at first oral feeding
  - Shorter time between surgery and initiation of oral feeding
- Negative Predictors
  - Presence of a genetic syndrome
  - "Longer" duration of any type of ventilator support
  - Involvement of a feeding therapist
Hypoplastic Left Heart Syndrome (HLHS)

- Congenital heart defect
- Underdeveloped left ventricle
- Classification: Cyanotic
- Early Intervention
  - Survival necessitates palliation w/n 1st few DOL
  - Goal: enable infant to function with a single ventricle cardiovascular system

Subjects + Fiberoptic Laryngoscopy Findings

- Subjects
  - 33 infants w/ HLHS
  - 18 infants s/p aortic arch reconstruction as part of biventricular repair

- Fiberoptic Laryngoscopy
  - Median 10 days, range 4-27 days
  - MBS: 5 swallows (2 liquid barium consistencies)

Results: HLHS (n = 33) after Norwood Procedure

- RLN injury
  - 3 (9%) – relatively uncommon

- Swallowing impairments
  - Abnormal MBS – 16 (48%)
  - Aspiration – 8 (24%)
  - Poor or absent suck – 7 (21%)
  - Poor swallow coordination – 3 (9%)

- All 3 pts with glottic gaps had aspiration on initial MBS
Results: Aortic Arch Repair (n = 18)

- RLN injury
  - 4 (25%)
- Swallowing impairments
  - Abnormal MBS – 10 (59%)
  - Aspiration – 6 (35%)

Skinner et al., 2005

Implications: Swallowing Dysfunction...

- Common after Norwood procedure
- May be related to factors other than VF status
- + RLN damage, other potential contributory factors are:
  - Loss of pharyngeal innervation
  - Glottic incompetence,
  - Diminished cough response
- Associated w/ increased length of hospital stay

Skinner et al., 2005

Aim: To compare GI complications and pharyngeal dysfunction following Norwood vs. hybrid procedures
**Study**

- 50 infants w/ HLHS
  - Norwood (n = 34)
  - Hybrid stage 1 Norwood (n = 16)
- Standardized protocol for evaluation of laryngopharyngeal function during period of data collection
- Retrospective review of findings

*Davis et al., 2013*

**Study: Feeding Evaluation Protocol**

- **MBS: criteria**
  - All pts. post-op stage 1 Norwood
  - Any pt. w/ abnormal flexible fiberoptic laryngoscopy
  - Any pt. w/ abn. oral feeding evaluation
- **MBS: f/u criteria**
  - 1 mo - if abn. swallow study + abn. VF eval
  - 3 mos – if abn swallow study + nl VF

*Davis et al., 2013*

**Feeding / Swallowing Findings (n = 33)**

- **MBS Findings**
  - 27 (82%) - Abnormal
  - 18 (37%) - Aspiration
  - Any pt. w/ abn. oral feeding evaluation
- **Oral Feeding (clinic) Eval**
  - 3 (25%) w/ nl exam, had aspiration on MBS

*Davis et al., 2013*
Conclusions

- Clinic evaluation was not sufficient for determining swallowing impairments + aspiration
- Nonetheless, clinic evaluation demonstrated abnormalities in:
  - Feeding behavior
  - Laryngopharyngeal motor and sensory function

Davis et al., 2013

Unpublished Report

Unpublished Report – Swallowing Impairments

- Retrospective review of VFSS 23 infants s/p S1P
- VFSS completed upon initiation of oral intake, as c/w the protocol for the institution’s cardiac team
  - $\bar{x} = 25$ days (range: 7 - 56 days) post-op
- Scored by consensus (2 SLPs) using a novel likert-scale metric developed to quantify physiologic function of swallowing and characteristics of bolus flow in bottle-fed infants

McGrattan et al., unpublished 2013
VFSS: Swallowing Impairments
- Sucking organization
- Timing of swallow onset
- Laryngeal vestibular closure
- PES opening

McGrattan et al., unpublished 2013

VFSS’s: Delays in Location & Timing of Swallow Initiation
- 83% w/ delay in location of swallow initiation
  - 11% w/ initiation bet. valleculae and pyriform sinuses
  - 89% w/ initiation in pyriform sinuses
- 96% w/ delay in timing of swallow initiation
  - 59% ≥1 sec. and ≤2 sec.
  - 41% ≥2 sec.

McGrattan et al., 2013

Penetration/Aspiration and Location of Swallow Onset
- No Penetration/Aspiration: 18%
  - 1 valleculae; 3 pyriform sinuses
- Penetration: 30%
  - 1 bet valleculae and pyriform sinuses; 6 pyriform sinuses
- Aspiration: 52%
  - 3 valleculae; 1 bet. valleculae and pyriform sinuses; 8 pyriform sinuses

McGrattan et al., unpublished 2013
Aim: Literature review + assessment of best practices of nutritional guidelines for first interstage period of infants with HLHS - Feeding Work Group of the National Pediatric Cardiology Quality Improvement Collaborative

Results/Recommended Feeding Guidelines: Oral Feeding Eval.

- **Strongly Recommended**: Oral feeds should be initiated following feeding evaluation
- Due to the high incidence of vocal fold injury and feeding dysfunction, a feeding evaluation should be conducted on all infants postoperatively to evaluate oral-motor coordination and aspiration risk

Slicker at al, 2013

Results/Recommended Feeding Guidelines: Oral Feeding Eval.

- Evaluation can be performed per institution preference.
- Once infant is **deemed safe** for oral feeding, trial feeds should be attempted prior to each NG feed or on top of continuous drip feeds
- During initial oral feedings, infants should continually be evaluated for evidence of low cardiac output and respiratory compromise
Results/Recommended Feeding Guidelines: Oral Feeding Eval.

- When infant takes ≥50 - 75% of their caloric goal orally for 48 hours, remove enteral feeding tube and attempt complete oral feeding regimen
- If infant struggles with oral feedings, consider ongoing therapies from SLP and/or a videofluoroscopic swallow study and exam by an otolaryngologist

Persistent Pulmonary Hypertension (PPHN)

Pathogenesis of Pulmonary Hypertension

- PPHN arises to failure of pulmonary resistance to decrease after birth
- R. ventricle needs to work harder to pump blood out to the lungs
- R. ventricle enlarges & thickens in response to this extra work
- With time, extra work can → R. side of the heart to fail
Persistent Pulmonary Hypertension (PPHN):
- By definition - disorder of newborn infants
- If 2nd PPHN, best tx plans include exploration and treatment of contributing conditions
  - e.g., repair of the underlying congenital heart defects, treatment of lung disease, as well as addressing less common 2nd causes.
- PPHN may complicate the course of older infants with chronic respiratory insufficiency due to bronchopulmonary dysplasia

Persistent Pulmonary Hypertension (PPHN)
- If 2nd secondary to another condition, best treatment is exploration and treatment of contributing conditions.
  - Tx may include repair of underlying congenital heart defect or management of lung disease
- PPHN may complicate the course of older infants with chronic respiratory insufficiency due to bronchopulmonary dysplasia (BPD)

PPHN: Implications for Feeding / Swallowing
- Aspiration-induced injury
- Nutritional adequacy
- Stressful child and caregiver interactions
**Caregiver Concerns**

- Initial – survival
- Roller coaster diagnostic procedures, medical and surgical interventions
- After which, feeding problems emerge as #1 concerns give need for infant to gain weight

Davis et al., 2008

**Caregiver Concerns About Feeding Challenges**

- Lengthy feedings, lasting up to 2 hours
- Frequent vomiting episodes
- Frequent feedings or bottle presentations
- Confusing infant hunger cues
- Mothers of infants with feeding problems expressed concern over infant weight gain and caregiver sleep deprivation, both of which contributed to parental stress.

Davis et al., 2008
**Transitioning Home: Feeding Challenges**

- Mothers of infants with feeding problems expressed concern over infant weight gain and caregiver sleep deprivation, both of which contributed to parental stress.
- Concerns about enduring long term effects on ability of child to feed orally

Davis et al., 2008

**Feeding Recommendations**

- Encourage mother-infant skin-to-skin contact and direct breastfeeding as early as possible
- Provide caregiver education – “cue-based” recommendations + support caregivers
- Attempt to schedule feeding in a manner that supports infant's regulation of sleep-wake cycles

Sable-Baus, 2011

**Thus Far, Focus of Literature**

- Enteral feeding guidelines, which in turn focus on physiological stabilization and do not always address the developmental milestones necessary to support oral feeding
- Future prospective studies are necessary to identify multimodal strategies to optimise early feeding

Sables-Baus et al., 2011
Future Needs

- Who is at greatest risk for feeding and swallowing problems?
- Which evaluations should be done + when is the information most useful?
- How do we balance feeding/swallowing recommendations with what is known/unknown about the ability to tolerate aspiration and neuroplasticity

References


Infants with Cardiopulmonary Disorders

Sinai C. Zyblewski, MD, MSCR
Assistant Professor
Pediatric Cardiology

I have no disclosures.

Vocal Cord Paresis

- Well described complication
- Association with dysphagia and feeding difficulties
Medical University of South Carolina

Norwood Subjects:
• Left true vocal fold paralysis - 9%
• Abnormal modified barium swallow - 48%
• Aspiration - 24%

Biventricular Repair Subjects:
• Left true vocal fold paralysis - 25%
• Abnormal modified barium swallow - 59%
• Aspiration - 35%
Cincinnati Children's Hospital Medical Center

- Overall incidence of vocal cord dysfunction - 58.7%
- Swallowing dysfunction with VC dysfunction - 21.6%
- Swallowing dysfunction without VC dysfunction - 7.7%

Texas Children's Hospital

- Vocal fold paresis – 19.7%
- Vocal cord paresis was associated with abnormal cough and gag, feeding difficulties, and modified diet at discharge.
Anatomy

Cardiac Surgical Risk Factors

- Aortic Arch Surgeries
  - Norwood Operation
  - Extended coarctation of aorta repair
  - Interrupted aortic arch repair
- Hybrid Procedure
- PDA Ligation
- ECMO

Hypoplastic Left Heart Syndrome
Norwood Operation

Hybrid Procedure

Environmental Hazards

THE ICU!!!
**Environmental Hazards**

**Morbidities**

- Increased aspiration risk
- Prolonged hospitalizations
- Increased risk for tube feeding dependence
- Increased risk for unexpected death at home after hospital discharge

**Institutional Practice Variations**

**WHO?**

- Symptomatic patients
  - Weak cry or hoarseness
  - Feeding difficulties
- Standardized protocols for specific patients
Institutional Practice Variations

WHAT?
- Bedside feeding evaluation
- Bedside laryngoscopy
- Modified barium swallow study (MBSS)
- Flexible fiberoptic endoscopic evaluation of swallow (FEES)

NOW WHAT???
- Thickened oral feeds
- Nasogastric tube feeds
- Gastrostomy tube feeds