Multidisciplinary Management of Fetal, Neonatal and Pediatric Airway Disorders

Sohit Paul Kanotra M.D.
Director, Pediatric Aerodigestive Center
Children’s Hospital of New Orleans
Assistant Professor, Otolaryngology-Head & Neck Surgery, Louisiana State University.

Financial Disclosure

I do not have any conflicts of interest
Multidisciplinary Pediatric Airway Clinic
Children’s Hospital New Orleans

- Multidisciplinary
- Pediatric Otolaryngology
- Pulmonary
- Gastroenterology
- Speech Language pathology
- Social Services
Review of Maternal and fetal outcomes for Perinatal Management of compromised fetal airway

Subspecialty considerations in EXIT

Ex-Utero Intrapartum Treatment (EXIT)

is a procedure whereby patients with airway obstruction undergo and, while , undergo before
EXPANSION OF INDICATIONS

Ex Utero Intrapartum Treatment

AIRWAY
- Extrinsic:
  - Teratoma
  - Lymphatic/Vascular malformation
  - Severe micrognathia
- Intrinsic:
  - Congenital High airway obstruction syndrome (CHAOS)
- Iatrogenic:
  - Tracheal clipping or balloon occlusion in Congenital diaphragmatic hernia

RESECTION
- Thoracic/mediastinal masses
- Congenital cystic adenomatoid malformations
- Bronchopulmonary sequestration
- Fetal lobar interstitial tumor

ECMO
- Severe Congenital heart disease
- Severe Congenital diaphragmatic hernia

SEPARATION
- Conjoined twins

Criterion for EXIT
- Diagnosis of a teratoma.
- Mass size greater than 5 cm
- Polyhydramnios or absence of fetal gastric fluid
- Signs of intrinsic airway obstruction
  - Hyperexpanded lungs
  - Flattened diaphragm.
- Difficulty Airway: Prenatal Imaging.
Review the multidisciplinary approach to the management of neonatal upper airway obstruction

Develop an algorithmic approach to the evaluation and management of neonatal airway obstruction

**Poiseuille’s Law**

\[ Q = \frac{\pi P r^4}{8n l} \]

- Q = Flow rate
- P = Pressure
- r = Radius
- n = Viscosity
- l = Length

**Multilevel airway obstruction**
Evaluation of Neonatal Airway Obstruction

Neonatal Drug Induced Sleep Endoscopy (DISE)

- Upper airway evaluation following simulation of sleep
- Allows to identify the pattern and level of airway obstruction
- Allows physician to tailor the treatment plan of each patient
Neonatal Drug Induced Sleep Endoscopy (DISE)

Algorithm for Multidisciplinary management of Neonatal Upper airway obstruction

- Clinical Evaluation
  - degree of respiratory distress and upper airway compromise,
  - oxygen saturation levels,
  - signs of neurological abnormalities, such as hypotonia

- Feeding and reflux evaluation
  - Feeding evaluation
  - Swallow study
  - Ph Probe

- Bedside Flexible Nasopharyngoscopy
  - Level of Obstruction
  - Degree of Obstruction
Algorithm for Multidisciplinary management of Neonatal Upper airway obstruction

- Level of Obstruction
- Multilevel Obstruction
- Tracheobronchial lesions

Most important

- Craniofacial issues

- Assess central apneas
- Severity of Obstructive episodes
- Oxygen saturations

Pyriform aperture stenosis

- Associated with single central incisor, holoprosencephaly and pituitary abnormalities (hypodevelopment and dysfunction)
- Diagnosis
  - CT
  - Magnetic resonance imaging (MRI) of the head
- Management:
  - No Intervention
  - If significant airway compromise
  - Sublabial Medial Maxillectomy
Choanal Atresia (Management)

• Unilateral atresia: Nonurgent repair. Can wait until -1yr

• Bilateral atresia: establish airway & feeding pathway; (McGovern nipple, oropharyngeal airway).

• Intubation not necessary unless mechanical ventilation required

• Surgical repair approaches
  i) Transnasal
  ii) Transpalatal (reserved for revision cases)
  iii) Transantral
  iv) Transseptal

Micrognathia / Retrolingual Obstruction

• Undersized mandible
• Pierre Robin Sequence
• Craniofacial Genetic disorders
  Stickler Syndrome
  Treacher Collins
  Hemifacial Microsomia
Micrognathia / Retrolingual Obstruction

- Conservative management
- Prone positioning
- Nasopharyngeal airway
- Nasal CPAP
- Observation
- Tracheostomy
- Tongue Lip adhesion
- Mandibular Distraction Osteogenesis

Intubation related airway injury

- Supraglottis
  - Absent to minor lesions
  - Oedematous protrusion of ventricular mucosa
  - Erythema or oedematous swelling of the ventricular bands
- Glottis
  - Non-specific swelling in Reinke's space of the vocal cords
  - Pressure-induced ischemic necrosis:
    - Ulcers at the medial aspect of the arytenoids with flanges of granulation tissue at vocal processes
    - Medial exposure of the cricoarytenoid joint
    - Posterior interarytenoid ulcer
- Subglottis
  - Non-specific oedematous swelling
  - Posterolateral cricoid ulcers
  - Concentric subglottic ulceration

- Patient
  - Age: infant - adolescent
  - Larynx: small size, abnormal shape, infection
  - Abnormal wound healing (fibrosis formation)
  - Systemic diseases: GOR, shock (infectious, cardiogenic)
    - Immuno-suppression, diabetes, anemia, hypotension:
      - Bronchopulmonary dysplasia
- ET tube
  - Oversized
  - Excessive hardness
  - Poor biocompatibility
- Intubation
  - Traumatic
  - Multiple
  - Prolonged
  - Followed by tracheostomy
- Nursing
  - Inadequate patient's sedation
  - Traumatic and repeated suction
  - Presence of nasoendotracheal tube
  - Ventilator-driven tube motion
Endotracheal Intubation related trauma

Acute lesions

Management of acute airway injury

- Failed extubation event should not be considered as an indication of tracheostomy

- Treatment consists of:
  re-intubation with a one-size smaller ET tube,
  topical application of an endolaryngeal plug of TOBRADEX® (tobramycin and dexamethasone ophthalmic ointment)
  Systemic antibiotics depending on the tracheal aspirate culture, as well as systemic corticosteroids.

- Post extubation: Adrenalin aerosols (50 mg/kg in 4 ml of NaCl 0.9%), iv Dexamethason (2 mg/kg), continuous positive airway pressure (CPAP), and heliox delivered through a face mask

- If these manoeuvres fail, an anterior cricoid split combined with a thyroid cartilage graft may be performed in order to avoid the need for tracheostomy.
LTR in the Infant

- This is an alternative to tracheotomy in small children who have left hospital, but returned with SGS and stridor.
  - Often post RSV, or ex-premmies
- Anterior thyroid alar graft, posterior cricoid split
- A posterior split is ideal for the young child (< 1 year)
  - Posterior split stabilizes rapidly in infants
  - Complete laryngofissure not required
- May be single staged
- Appropriate for children as small as 2.5kgs
Single stage Laryngotracheal reconstruction using thyroid ala graft

(Exposure & Graft Harvest)
Post operative

Describe the management of common pediatric airway disorders

Review the management of Airway Stenosis

Describe the role of a Multidisciplinary team in the management of children with complex Aerodigestive problems
Common causes of Stridor

Laryngeal (60%)
- Laryngomalacia (60%)
- Subglottic stenosis (20%)
- VC palsy (13%)
- Others (7%)

Tracheal (15%)
- Tracheomalacia (45%)
- Vascular compression (45%)
- Stenosis (5%)

Bronchial & Tracheal infections: 5%
Miscellaneous: 15%

Laryngomalacia

- Most common congenital anomaly of the larynx
- absent at birth, begin: first few weeks of life, increase over several months, and resolve by 18-24 months of life.
Classification of Laryngomalacia

Functional Endoscopic evaluation of swallowing Clinic

- Evaluation of Infants and Children with Swallowing Dysfunction
- Peds OTO+ SLP
- Scopes done by Peds OTO
- Evaluation of swallowing done by SLP
FEES (Laryngomalacia)

Laryngomalacia (Management)

- Mild: Reassurance
- Feed changes:
  - Thickening of the feeds
  - Pacing
  - Antireflux precautions
- Medical Management: Reflux management
- Improved feeding: H2 blocker therapy (Ranitidine 3mg/kg, tid)
- PPI indicated for refractory or breakthrough symptoms.
Laryngomalacia (Management)

**INDICATIONS FOR SURGERY**

- Cor pulmonale
- Pectus excavatum
- Hypoxia/Hypercapnia
- Respiratory compromise
- Failure to thrive
- Weight loss
- Sleep apnea

Laryngomalacia
Supraglottoplasty with CO2 Laser

Post operative (1 month)
To describe a swallowing index that assess the parental perception of their child’s swallowing before and after supraglottoplasty.
Materials & Methods

• 51 single surgeon supraglottoplasties over a 2 year period were reviewed.
• 34 parents had completed the Swallowing Index Questionnaire - 6 questionnaires were excluded for being incomplete
• Total of 28 patients were included

Demographic Profile

<table>
<thead>
<tr>
<th></th>
<th>Mean +/- SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gestational Age (weeks)</td>
<td>37 ± 3.45</td>
<td>23-40</td>
</tr>
<tr>
<td>Age at Diagnosis (Months)</td>
<td>4.17 ± 4.61</td>
<td>0.5-24</td>
</tr>
<tr>
<td>Age at Surgery (Months)</td>
<td>6.43 ± 4.60</td>
<td>2-24</td>
</tr>
<tr>
<td>Sex: Males Females</td>
<td>15(53.5%) 13(46.5%)</td>
<td></td>
</tr>
<tr>
<td>Weight at Presentation(kg)</td>
<td>6.08±2.29</td>
<td>2.50 - 13.5</td>
</tr>
<tr>
<td>Weight at time of Surgery(kg)</td>
<td>6.87±1.9</td>
<td>3.52-14.70</td>
</tr>
<tr>
<td>Weight at 1 month(kg)</td>
<td>7.47±2.14</td>
<td>4.85-15.0</td>
</tr>
<tr>
<td>Weight at 3 months(kg)</td>
<td>8.6±1.9</td>
<td>6.13-15.6</td>
</tr>
</tbody>
</table>

Severity

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Moderate</td>
<td>9</td>
</tr>
<tr>
<td>Severe</td>
<td>19</td>
</tr>
</tbody>
</table>
### Pre & Postoperative Swallowing Index Scores

#### Symptoms And Clinical Dysphagia evaluation

<table>
<thead>
<tr>
<th>Heading</th>
<th>Question</th>
<th>Preoperative Mean ± SD</th>
<th>Postoperative Mean ± SD</th>
<th>p-value</th>
<th>CI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Q1: Are you concerned about your child's swallowing?</td>
<td>3.56±1.07</td>
<td>1.75±0.7</td>
<td>0.000</td>
<td>1.34,2.22</td>
</tr>
<tr>
<td></td>
<td>Q2: How often does your child choke during feeding?</td>
<td>3.43±1.07</td>
<td>1.89±0.87</td>
<td>0.000</td>
<td>1.24,2.64</td>
</tr>
<tr>
<td></td>
<td>Q3: Are your child have breech or reflux during feeding?</td>
<td>3.21±1.25</td>
<td>1.60±0.68</td>
<td>0.000</td>
<td>1.14,2.07</td>
</tr>
<tr>
<td></td>
<td>Q4: How often does your child not eat?</td>
<td>3.11±1.5</td>
<td>2.10±0.9</td>
<td>0.000</td>
<td>0.59,1.60</td>
</tr>
<tr>
<td></td>
<td>Q5: How often do you have to modify the diet to feed the child?</td>
<td>2.03±1.4</td>
<td>1.54±0.92</td>
<td>0.017</td>
<td>0.035,1.036</td>
</tr>
</tbody>
</table>

#### Social

<table>
<thead>
<tr>
<th>Question</th>
<th>Preoperative Mean ± SD</th>
<th>Postoperative Mean ± SD</th>
<th>p-value</th>
<th>CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q8. Does your child’s swallowing problem cause social problems?</td>
<td>1.16±1.20</td>
<td>1.07±0.05</td>
<td>0.07</td>
<td>-0.03,0.819</td>
</tr>
<tr>
<td>Q7. Does your child’s swallowing problem affect your ability to do daily activities?</td>
<td>2.01±1.2</td>
<td>1.25±0.33</td>
<td>0.001</td>
<td>0.37,1.19</td>
</tr>
</tbody>
</table>

#### Psychological

<table>
<thead>
<tr>
<th>Question</th>
<th>Preoperative Mean ± SD</th>
<th>Postoperative Mean ± SD</th>
<th>p-value</th>
<th>CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q9. How often are you satisfied with the amount of food per session?</td>
<td>1.50±0.57</td>
<td>3.09±1.38</td>
<td>0.000</td>
<td>1.50,2.03</td>
</tr>
<tr>
<td>Q8. Are you anxious about your child's swallowing problem?</td>
<td>3.92±1.42</td>
<td>1.35±0.62</td>
<td>0.000</td>
<td>1.46,2.60</td>
</tr>
<tr>
<td>Q10. Is your child's weight a source of concern for you?</td>
<td>2.89±1.09</td>
<td>1.34±0.46</td>
<td>0.000</td>
<td>1.33,1.917</td>
</tr>
</tbody>
</table>

- **Mean Preoperative:** 28.32
- **Mean Postoperative:** 15.57

![Swallowing Index Graph](image-url)
## Subglottic stenosis

### Cotton-Myer grading system

<table>
<thead>
<tr>
<th>AGE</th>
<th>ETT</th>
<th>ID=2.0</th>
<th>ID=2.5</th>
<th>ID=3.0</th>
<th>ID=3.5</th>
<th>ID=4.0</th>
<th>ID=4.5</th>
<th>ID=5.0</th>
<th>ID=5.5</th>
<th>ID=6.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preterm</td>
<td>No</td>
<td>40%</td>
<td>0%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preterm</td>
<td></td>
<td>58%</td>
<td>30%</td>
<td>0%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-3 mo</td>
<td>Lumen</td>
<td>68%</td>
<td>48%</td>
<td>26%</td>
<td>0%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3-9 mo</td>
<td></td>
<td>75%</td>
<td>59%</td>
<td>41%</td>
<td>22%</td>
<td>0%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9m to 2 yr</td>
<td></td>
<td>80%</td>
<td>67%</td>
<td>53%</td>
<td>38%</td>
<td>20%</td>
<td>0%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 yr</td>
<td></td>
<td>84%</td>
<td>74%</td>
<td>62%</td>
<td>50%</td>
<td>35%</td>
<td>19%</td>
<td>0%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 yr</td>
<td></td>
<td>86%</td>
<td>78%</td>
<td>68%</td>
<td>57%</td>
<td>45%</td>
<td>32%</td>
<td>17%</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td>6 yr</td>
<td></td>
<td>89%</td>
<td>81%</td>
<td>73%</td>
<td>64%</td>
<td>54%</td>
<td>43%</td>
<td>30%</td>
<td>16%</td>
<td>0%</td>
</tr>
</tbody>
</table>

Percentage Obstruction Using Leak Around Endotracheal Tube
Grading of Stenosis

<table>
<thead>
<tr>
<th>Grade I</th>
<th>Grade II</th>
<th>Grade III</th>
<th>Grade IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Obstruction</td>
<td>50% Obstruction</td>
<td>71% Obstruction</td>
<td>No Detectable Lumen</td>
</tr>
</tbody>
</table>

Chapter 13

Advances in the Management of Pediatric Laryngotracheal Stenosis

Sahil Paul Kanota,

- Hypopharynx: pooling of secretions
- Supraglottis
- Vocal fold mobility
- Dynamic lesions in the nose—oropharyngeal area
- Pharyngeal collapse
- Tracheomalacia

To access the site, degree and extent of laryngotracheal stenosis:
- Grading of stenosis according to the Cotton-Myer grading system
- Glottic involvement: posterior glottis stenosis and vocal cord synchiae
- Assessment of tracheotomy site: suprastomal collapse, granuloma, tracheomalacia and tracheal granulomas

In case of vocal cord immobility, to differentiate vocal fold paralysis from progressive stenosis with or without cricopharyngeal joint dysfunction
- Arterial palpation
- Bronchoscopic lavage:
  - Lipid laden macrophages for chronic aspiration
  - Bacteriological analysis of tracheal aspirates

To evaluate gastroesophageal reflux: reflux is significant if the time with pH less than 4 is greater than 5-10% at the lower probe and greater than 4% at the upper probe

- Rule out MRSA
- Functional endoscopic evaluation of swallowing:
  - Laryngeal mobility: vocal cord motion/laryngeal elevation
  - Pharyngeal transit
  - Premature spillage
  - Laryngeal penetration
  - Aspiration
- Hypopharyngeal pooling
- Videofluoroscopic evaluation of swallowing
- Clinical dysphagia evaluation by a speech language pathologist
Pediatric Laryngotracheal Stenosis

Flexible laryngoscopy
Direct Laryngoscopy and Rigid Bronchoscopy
Flexible Bronchoscopy
Esophagoscopy with Biopsies
Multichannel pH impedance testing
Videofluoroscopic swallow assessment
Functional endoscopic evaluation of swallowing
Nasal/Tracheal cultures

Grade 1
Radial Incision with Balloon dilatation
* Thin circumferential scars

Grade 2
Anterior costal Cartilage graft
Thick stenosis
No Glottic involvement

Anterior and Posterior costal cartilage graft with stenting
Thick circumferential stenosis
Glottic involvement

Grade 3 & 4
Anterior and Posterior costal cartilage graft with stenting
Thick circumferential stenosis
Significant Glottic involvement

Partial Cricotracheal resection
Severe Grade III and IV stenosis
No Glottic involvement
At least 3-4mm of stenotic free area below the true vocal cord
Revision Laryngotracheal Resection

Extended Partial Cricotracheal resection

Cervical Slide Tracheoplasty

Anterior costal cartilage graft
Cricotracheal Resection

**Indications**
- Severe stenosis (Gd III or IV)
- Concentric scarring
- Salvage procedure
- Congenital anomaly of cricoid or upper trachea
- Structurally inadequate subglottis
- Inflammatory subglottic stenosis – Wegener’s

**Contraindications**
- Stenosis involves cords
- Grade I or II subglottic stenosis
- Previous low tracheal surgery
- Previous TEF repair or laryngeal cleft repair

**Best Candidates for CTR** are Grade 3/4 stenosis with a clear margin >3mm between the stenosis and the vocal folds

**Extended Partial Cricotracheal Resection**
Extended Partial Cricotracheal Resection

Postoperative
Tracheal Stenosis

Tracheal resection yields better results than laser incision and balloon dilatation

Major complications are
1. Anastomotic dehiscence
2. Restenosis

Grade 3 Tracheal Stenosis undergoing Tracheal resection with end to end anastomosis
Future Directions

CHNOLA ‘TRACHEOSTOMY and AIRWAY SAFETY’ Initiative

Multidisciplinary Conference for
Clinical Consensus statement on Pediatric Tracheostomy

ROBOTIC AIRWAY SURGERY

3D Printout

CAD Model
Conclusion

• Pediatric Airway Obstruction requires a multidisciplinary approach

• A dedicated Airway Team is essential to optimize results in complex pediatric Laryngotracheal stenosis

• *Think before you trach*: Failed extubation event should not be considered as a indication of tracheostomy