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7:30  Registration begins

8:00 am  Introduction, Welcome  
David Polaner, MD, FAAP

8:15 am  Embryology and Development of the Airway  
Robert Holtzman, MD

9:00 am  Question and Answer  
Holtzman

9:05 am  Reappraisal of the Pediatric Airway Anatomy  
Scott Markowitz, MD

9:35 am  Airway Imaging  
Bruno Marciniak, MD

10:20 am  Question and Answer  
Markowitz & Marciniak

10:30 am  Break/View Exhibits

11:00 am  Cuffed Endotracheal Tubes in Children—Beneficial and Safe  
Andreas Gerber, MD

11:45 am  Real Time Respiratory Data to Guide Ventilation  
David Polaner, MD, FAAP

12:15 pm  Question and Answer  
Gerber & Polaner

12:30 pm  Lunch Room: Yale, Lobby & Terrace  
& View Exhibits

1:30 pm  Abstracts Presentations

2:00 pm  Cystic Fibrosis: Update and Recent Advances  
Scott Sagel, MD

2:40 pm  Flexible Bronchoscopy and Laryngotracheomalacia  
Robin Deterding, MD

3:20 pm  Laryngotracheal Reconstruction  
Peggy Kelley, MD

4:00 pm  Question and Answer  
Sagel, Deterding, and Kelley

4:15 pm  PANEL: Perioperative Management of Asthma  
Deterding, Szolnoki, Rabinovitch; Polaner-Moderator

5:15 pm  Evaluation

5:30 pm  Adjourn
SATURDAY, 18 JUNE 2011

7:30 am  Registration begins
7:45 am  Welcome  
          Geoffrey Lane, MB
8:00 am  **Laryngospasm: Pathophysiology & Treatment**  
          Thomas Erb, MD
8:45 am  **Cricoid Pressure-Unfavorable and Unessential**  
          Andreas Gerber, MD
9:15 am  **Operative and Non-Operative Management of Mandibular Hypoplasia**  
          Greg Allen, MD
10:00 am  Questions and Answers  
           Erb, Gerber, and Allen
10:30 am  Break/View Exhibits
10:45 am  **Opening the Upper Airway-Maneuvers in Pediatric Anesthesia**  
           Thomas Erb, MD
11:30 am  **Base of Tongue/Epiglottis Collapse**  
           Robert Yellon, MD
12:00 pm  Questions and Answers  
           Erb and Yellon
12:15 pm  Lunch Room: Yale, Lobby & Terrace  
           & View Exhibits
1:15 pm  **Dexmedetomidine**  
          James Cain, MD
1:45 pm  **Effects of Dexmedetomidine and Propofol on Airway Anatomy**  
          Mohamed Mahmoud, MD
2:30 pm  **Videostroboscopy**  
          Lawrence Borland, MD and Joseph Dohar, MD
3:00 pm  Questions and Answers  
          Cain, Mahmoud, Dohar, and Borland
3:15 pm  **PANEL: Airway Management Outside the OR**  
          Dobyns, Lane, Givens, Agarwal-Moderator
4:15 pm  **Abstracts**
5:00 pm  Evaluation
5:15 pm  Adjourn
International Symposium on the Pediatric Airway 6
PROGRAM

SUNDAY, 18 JUNE 2011

7:30 am  Registration begins
8:00 am  **Introduction**  
          Lawrence Borland, MD
8:10 am  **The Larynx**  
          Mona Abaza, MD MS
9:00 am  **Sleep Studies and Evaluation for Surgery**  
          Norman Friedman, MD
9:45 am  **Drugs and Obstructive Sleep Apnea**  
          David Polaner, MD
10:30 am **Trisomy 21 and the Airway**  
          Lawrence Borland, MD
11:00 am **Teaching and Evaluating Airway Skills**  
          Geoffrey Lane, MB
11:45 am Questions and Answers  
          Abaza, Friedman, Polaner, Borland, and Lane
12:15 pm Evaluation
12:30 pm Lunch – informal Room: Yale, Lobby & Terrace
12:30 pm  **Airway Workshop**  
          Geoffrey Lane, MB, Judit Szolnoki, MD, Rita Agarwal, MD, Jennifer Zieg, MD
2:00 pm Evaluations
2:15 pm Adjourn
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<th>TYPE OF AFFILIATION (salary, royalty, speaking honorarium, researcher, board of directors remuneration, consulting fee, stock options)</th>
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Laryngospasm: Pathophysiology and Treatment

Thomas O. Erb  M.D., M.H.S.
University Children's Hospital
Basel, Switzerland

Why do we care?

Perioperative Cardiac Arrests

- 80% Laryngospasm

Pediatric POCA Registry 1999 – 2004
Bhananker et al. 2007

Objectives

- Review Protective Upper Airway Reflexes
  - Laryngospasm
  - Pathophysiology
  - Ethiology
- Presentation of Clinical Model
- Discuss Clinical Management
  - Prevention strategies
  - Treatment of established laryngospasm

Larynx = Protectionorgan

- Regulation based on reflexes
  - Coughing Reflex
  - Expiration-Reflex
  - Spasmodic panting
  - Central Apnoe
  - Glottic Spasm
  - Laryngospasmus

Pathophysiology Laryngospasm I

- 1. Shutter effect
- 2. Ball valve effect

International Symposium on the Pediatric Airway 6
17 June 2011 - 19 June 2011
Pathophysiology Laryngospasm

- Laryngospasm = complete Obstruction
  - Vocal cords
  - Vocal cords & False cords
- Stridor <==> Laryngospasm
- Stimulation of the mucosa
  - Glottic
  - Supraglottic
- Synaptic transmission modified by
  - Hypoxia
  - Hypercarbia
  - Fink BR Anesthesiology 1956

Ethiology Laryngospasm

- Stimulation of Mechano / Chemo / Thermo - Receptors
- Incidence in children: dependent on development?
  - transient laryngeal hypersensitivity in animals
- Spatial & temporal summation of excitatory stimuli „focal seizure“ (Sasaki Ann Otol 1977)
- Central mechanisms not exactly characterized

Laryngospasm: Endoscopic picture

Laryngeal Reflex Responses

- Glottis
- Larynx

Laryngeal Reflex Responses: Cough

Tagaito et al. Anesthesiology 1998

Laryngeal Reflex Responses Expiration reflex

Tagaito et al. Anesthesiology 1998
Laryngospasm: Clinical Studies

Complete closure of the larynx
- Difficulty of exact characterization in the clinical setting
  - Definitions used in studies
    - Cyanosis (any cause / with evidence of airway obstruction)
    - Stridor
    - Complete airway occlusion ± muscle rigidity (abdominal and chest walls)
  - Incidence: large range
    - 1/1000 Borgoyne LL et al. Ped Anesth 2008
    - 200/1000 Batra YK et al. Ped Anesth 2005

Experimental Approach (Stimulation model)

Background:
- Relevant clinical problem
- In 1-2% of the children undergoing anesthesia

MODEL
- Standardized stimulus
- Standardized analyses

Experimental Model

Experimental Setting

Treatment of Laryngospasm:
GOALS

Prevention
- "best treatment"

Therapy
- Oxygen
- Ventilation
Prevention of Laryngospasm

- Timing of anesthetic procedures
- Drugs:
  - Propofol vs. Sevoflurane
  - Sevoflurane concentration
  - Lidocaine i.v.
  - Opioids (Fentanyl)

High concentration of sevoflurane
- Observational study
- Response to spraying the larynx with lidocaine

Sevoflurane: Effect of higher concentration

Impact of i.v. Lidocaine (2mg/kg)

Impact of Fentanyl during Sevoflurane Anesthesia
Summary: Pharmacologic Laryngospasm Prevention Strategies

Risk ↓
- Propofol << Sevoflurane
- Lidocaine i.v.

Risk →
- Fentanyl

Laryngospasm Therapy Milestones:
- Oxygenation
- Airway Opening
- Ventilation
- Sedation
- Neuromuscular Blockade

Laryngospasm Denver 2011 TOErb

Oxygenation

- 100% Oxygen
- CPAP/PEEP (10 cm H₂O)
  - Cave: stretch reflexes
  Holubi, Ped Anest 2008

Laryngospasm Denver 2011 TOErb

Airway Opening Ventilation

- Jaw thrust
  - Most effective airway opening manoeuvre
  Reber Eur Resp J 2001 17 1239
  - „Laryngospasm Notch”
- Oral airway ?
- Ventilation
  - Avoid high peak pressures
    - abdominal distension
    - Stretch reflexes
  Larson CP Anesthesiology 1998

Laryngospasm Denver 2011 TOErb

Sedation

Propofol
Is there a role in the treatment of laryngeal spasms?
Mehran Ped Anest 2002

N = 20
13     3
IPPV   Propofol Succinylcholine
100% O₂ (0.8 mg/kg)

CAVE No control!
Bias: time effect

Laryngospasm Denver 2011 TOErb

Neuromuscular Blockade

Succinylcholine

Route Dose (mg/kg)
I.v. / I.m. 1 *
L.m.  4

* smaller doses may work as well
Walker et al 2007

Nondepolarizing Agents

Laryngospasm Denver 2011 TOErb

Erb, Thomas, MD, MHS
Laryngospasm: Pathophysiology and Treatment

International Symposium on the Pediatric Airway 6
17 June 2011 - 19 June 2011
Laryngospasm Treatment:
Summary

Prevention measures likely to modify the clinical course

However: may happen at each and every case

Be prepared!
Cricoid pressure - Unfavourable and Unnecessary

Andreas C. Gerber MD, KD
University Children’s Hospital
Zurich, Switzerland

Cricoid pressure unfavourable and unnecessary

- No conflict of interests

CP interferes with MRSI

- Smooth induction of anesthesia
- Gentle mask ventilation
Regurgitation - Aspiration

- Regurgitation when barriere P < intragastric P
- Lower Esophageal Pressure (LEP) > 16cm H₂O (24/31)
- CP lead ↓29% LEP and ↓44% of barriere pressure
- Aspiration is usually an active process
- Coughing, retching, forceful inspiration lead to aspiration
- CP can lead to straining and retching

Why is CP so attractive? (difficult to abandon?)

- It is (looks) simple
- It is (looks) logical
- It is (looks) effective
- It is time-honoured
- It is standard of care

The anatomical basis of CP

- Compression of the upper esophagus between cricoid cartilage and vertebral body (C5)
- With neck extended (tonsillectomy position) originally
- Possible lateral deviation of esophagus with CP
The anatomical basis of CP

- Rice 2009 MRI:
  Behind the Cricoid cartilage lies the hypoharynx
  Cricoid and hypopharynx behave as anatomical unit
  Hypopharynx is compressed despite lateral movement

Published evidence suggesting CP prevents regurgitation/aspiration

- Sellick 1961: 23/26 high risk case, 3 regurgitation after release
- Wraith 1983: force to prevent reflux of saline in women 44 N
- Neelakanta 2003: case report

Published evidence suggesting CP fails to prevent aspiration

- Case reports (Whittington 1979, Williamson 1989)
- Surveys (Howells 1983, Kopka 2004)
- Closed claim analysis (Cheney 2000) 67/17
- Confidential Enquiries into Maternal Deaths (3)
- Fenton 2009: n=4891 GA with intubation; 61% CP, 139 vomiting;
  77†: 11 associated with regurgitation, 9 with CP
- AIMS (Kluger 1999) 133/4
CP performance is unsatisfactory

- Correct pressure: "firm"; 44N; 20–40N; 10–30N
- Single handed – double handed
- CP can be trained, proficiency disappears fast
- Most anaesthetists think CP is essential in RSI
- The majority of physician, nurses, OR-personnel are unable to apply CP correctly ***

Does CP prevent pulmonary aspiration?

- Brimacombe 1997: "There have been no studies proving that CP is beneficial, yet there is evidence that it is often ineffective and that it may increase the risk of failed intubation and regurgitation".
- Neilipovitz 2007: "Evidence affirming a role for CP in preventing aspiration is unavailable. Its continued use during RSI is based on anecdotal evidence and expert opinion: it has likely achieved the status of standard of care and it is unlikely that a large RCT will be forthcoming that assess its role in high-risk patients."

Is pulmonary aspiration still as threatening?

- Edwards 1956: "regurgitation and vomiting was the largest single cause of death"
- Confidential Enquiry into Maternal Death in England on Wales show decreasing incidence since.
- Harrison 1978: fatal aspiration 1/45'000-1-240'000
- Maternal death 1994-2005 2 †
- NAP4 2008/2009: 36 aspirations, (8 †,2 brain d)
Today’s airway management (LMA)

- Kluger 1999: Aspiration during anaesthesia. AIMS

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Control</th>
<th>Aspiration</th>
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<tr>
<td>Tracheal tube</td>
<td>12</td>
<td>4</td>
</tr>
<tr>
<td>Mask</td>
<td>12</td>
<td>2</td>
</tr>
<tr>
<td>Mask insertion</td>
<td>100</td>
<td>10</td>
</tr>
</tbody>
</table>

NAP4:
- Incidence of aspiration with LMA 0.1-0.02%
- Brimacombe 1995, Keller 2004 (3†, 20)

In children pulmonary aspiration is rare and relatively benign

- Borland 1998: 50’880 52 (0.1%) no † 12 hospital admission, 4 cancellation of surgery, intubation with or without ventilation in 15
- Warner 1999: 63’180 GA, 24 aspirations (0.04%) 15 no symptoms >2h, no † (all at risk had CP)
- Murat 2004: 24’165 GA 19 aspirations (0.08%) no mortality

“Nearly all cases of pulmonary aspiration in our study occurred in patients who gagged or coughed during airway manipulation or during induction of anaesthesia in which paralysis with muscle relaxants was either not present or insufficient to prevent a gag or cough”

Can CP cause harm?

- Interference with ventilation
- Interference with intubation
- Interference with LMA-insertion/ventilation
  - Rare complications
    - esophageal rupture
    - fracture of cricoid
    - hemorrhage
    - movement of cervical spine?
    - pressure response?
CP’s effect on ventilation

- Reduced tidal volume
- Increased peak inspiratory pressure
- Obstruction of ventilation
  (10 studies partial, 2 complete)

CP’s effect on intubation

- Optimal external pressure ≠ cricoidal pressure!
- Turgeon 2005: No difference!
- MRI studies show deformation of larynx
- Endoscopy studies show mostly worse laryngoscopic view (occlusive compression)
- Walker 2010:

CP’s effect on LMA insertion/ventilation

- Insertion of LMA with CP more difficult
  (Success 94% → 67%)
- Ventilation through LMA more difficult
- Tracheal intubation through LMA less successful
  (Success 76% → 40%) (Brimacombe 1995)
- Gastric insufflation with LMA not decreased
  (Aoyama 1996; Asai 1996)
**Recommendations**

- **Vanner 2009:** “It is important that cricoid pressure is released if intubation is difficult as this may improve the view at laryngoscopy and allows accurate passage of a bougie.”

- **Brimacombe 1995 and Difficult Airway Society of Great Britain and Ireland 2007** recommend: *Release of cricoid pressure as needed during mask ventilation and also for Laryngeal Mask Airway insertion in “cannot intubate, cannot ventilate” situations.*

**Infants and children**

- Do not tolerate CP when awake
- Do often not tolerate preoxygenation
- Tolerance of apnea is short
- Untimely CP causes retching and gagging
- The risk of pulmonary aspiration is small
- Pulmonary aspiration had no mortality recently
- Ventilation should not be impeded
- Intubation should not be complicated
- LMA insertion should not be made more difficult.

**Avoiding pulmonary aspiration - but .....**

Glencorelli 2010

<table>
<thead>
<tr>
<th>Complication</th>
<th>N (%)</th>
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<tbody>
<tr>
<td>Moderate hypoxemia (SpO2 80-89%)</td>
<td>20 (3.9)</td>
</tr>
<tr>
<td>Severe hypoxemia (SpO2 &lt; 80%)</td>
<td>18 (1.7)</td>
</tr>
<tr>
<td>Bradycardia (HR &lt; 40 bpm)</td>
<td>5 (0.9)</td>
</tr>
<tr>
<td>Hypotension (SBP &lt; 70 mmHg)</td>
<td>8 (0.9)</td>
</tr>
<tr>
<td>Difficult intubation</td>
<td>18 (1.7)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>69 (6.4)</strong></td>
</tr>
</tbody>
</table>
There are more important things to do than CP

- Reassuring surroundings - no hectic
- Smooth induction of anesthesia
- Deep level of anesthesia
- Complete muscle paralysis
- Oxygenation and ventilation with PIP < 15 cm H₂O
- Best conditions for intubation or LMA

CP is unfavourable and unnecessary

- Whether CP prevents pulmonary aspiration is debatable
- That CP interferes with Modified Rapid Sequence Induction in children is obvious
- There are more important things than CP, when anesthetising a child at risk!

Thank you!
Operative and Non-Operative Management of Mandibular Hypoplasia

Gregory C. Allen, MD, FACS, FAAP
Pediatric Otolaryngology

The Problem
Mandibular hypoplasia
Airway obstruction
Poor feeding

Pierre Robin Sequence
1822 - St. Hilaire
1846 - Fairbairn
1911 - Shukowsky

Pierre Robin (1923, 1934) - used term "glossoptosis" and stressed how this symptom complex presented a "grave danger" for newborn infants
Pierre Robin Sequence

Originally called Pierre Robin Syndrome
Estimated to occur in 1:2,000 to 1:30,000 live births

Diagnosis

• The diagnosis of PRS is only the first step, not the last.
• Fewer than 20% have this as an isolated complex!

Syndromes and PRS

<table>
<thead>
<tr>
<th>Syndrome</th>
<th>Percentage</th>
</tr>
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<tbody>
<tr>
<td>Stickler syndrome</td>
<td>34%</td>
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<tr>
<td>Isolated (nonsyndromic) PRS</td>
<td>17%</td>
</tr>
<tr>
<td>Velocardiofacial syndrome (DiGeorge complex)</td>
<td>11%</td>
</tr>
<tr>
<td>Fetal alcohol syndrome</td>
<td>10%</td>
</tr>
<tr>
<td>All other syndromes</td>
<td>28%</td>
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When is airway intervention necessary?

• Clinical
• Desaturations
• Poor feeding or FTT
• Sleep study or serial sleep studies

Airway intervention in PRS

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<tr>
<th></th>
<th>n</th>
<th>None</th>
<th>NP tube, positioning</th>
<th>Trach</th>
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</thead>
<tbody>
<tr>
<td>Syndromic</td>
<td>12</td>
<td>1</td>
<td>5</td>
<td>6 (50%)</td>
</tr>
<tr>
<td>Nonsyn</td>
<td>38</td>
<td>13</td>
<td>23</td>
<td>2 (5%)</td>
</tr>
<tr>
<td>Total</td>
<td>50</td>
<td>14</td>
<td>28</td>
<td>8 (16%)</td>
</tr>
</tbody>
</table>


Treatment modalities

• Positioning and O$_2$
• Nasogastric feeding tube
• Nasal airway or nasopharyngeal tube (NPT)
• Tongue-lip adhesion or glossopexy
• Mandibular distraction osteogenesis (MDO)
• Tracheostomy
Nasopharyngeal tube (NPT)

- Same principle as NGT but you breath through it!
- Is it a safe “long-term” solution?
- Difficult to maintain for some parents.

Mandibular Distraction Osteogenesis

- Cut the bone.
- Slowly move cut surfaces apart.
- New bone grows in between.

Distraction Osteogenesis

- Gavriel Ilizarov, 1960's
- Kurgan, Siberia
- Many patients with difficult traumatic and developmental limb deformities.
- Limited resources…developed new technique.

Mandibular Distraction Osteogenesis

- McCarthy, 1992
- Series of 4 patients (average age = 78 mo)
- Successfully underwent gradual distraction of the mandible without
  - Bone grafting
  - Transfusion
  - Intermaxillary fixation.
Technique

- Imaging/Planning
- Device Placement
- Osteotomy/Corticotomy
- Latency (0-3 d)
- Distraction (10-21 d)
- Consolidation (4-8 wks)
- Device removal
Operative and Non-Operative Management of Mandibular Hypoplasia

Early Intervention: Distraction Osteogenesis of the Mandible for Severe Airway Obstruction
Study design

Primary objective
- Determine short term benefits of early intervention in neonates who underwent (MDO) within the first 90 days of life

Hypothesis
- Patients who undergo MDO avoid tracheotomy, have shortened hospital course, fewer invasive procedures, fewer home care needs, and are able to maintain weight

Study Design

5 year retrospective chart review (2004-2010)
- 32 consecutive patients who underwent MDO
- 24 meet study criteria

Inclusion Criteria:
- Pierre Robin sequence
- Isolated or syndromic
- Severe neonatal airway obstruction and feeding difficulty
- MDO performed within first 90 days of life

Results

<table>
<thead>
<tr>
<th>Total, No. (%)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Patients</td>
<td>24 (100)</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>11 (45.8)</td>
</tr>
<tr>
<td>Female</td>
<td>13 (54.2)</td>
</tr>
<tr>
<td>Premature</td>
<td>5 (20.8)</td>
</tr>
<tr>
<td>Genetics</td>
<td></td>
</tr>
<tr>
<td>Isolated PRS</td>
<td>17 (70.8)</td>
</tr>
<tr>
<td>Syndromic</td>
<td>7 (29.2)*</td>
</tr>
</tbody>
</table>

*5 syndromic patients were premature, and 2 syndromic patients were term.

Results: Hospital Course

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age at admission, days (SD)</td>
<td>9 (17.7)</td>
</tr>
<tr>
<td>Mean age at surgery, days (SD)</td>
<td>30.3 (20.4)</td>
</tr>
<tr>
<td>Mean length of post-operative intubation, days (SD)</td>
<td>6.2 (2.8)</td>
</tr>
<tr>
<td>Mean length of total hospital stay, days (SD)</td>
<td>38.3 (19.6)</td>
</tr>
<tr>
<td>Mean Age at discharge, days (SD)</td>
<td>47.3 (22.5)</td>
</tr>
<tr>
<td>POD #, day (range)</td>
<td>16 (6-46)</td>
</tr>
</tbody>
</table>

Results: Discharge

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Discharge Status, No. (%)</td>
<td></td>
</tr>
<tr>
<td>Home O2</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Feeding</td>
<td></td>
</tr>
<tr>
<td>Normal</td>
<td>12 (50)</td>
</tr>
<tr>
<td>Supplemental</td>
<td>10 (41.7)</td>
</tr>
<tr>
<td>Post-operative NG</td>
<td>5 (20.8)</td>
</tr>
<tr>
<td>G-tube</td>
<td>1 (4.2)</td>
</tr>
<tr>
<td>Repeat distraction</td>
<td></td>
</tr>
</tbody>
</table>
Results: Distraction

<table>
<thead>
<tr>
<th></th>
<th>Value (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deficiency by CT, mm</td>
<td>15.1 (3.1)</td>
</tr>
<tr>
<td>Length of distraction,</td>
<td>8.3 (2.3)</td>
</tr>
<tr>
<td>Amount distracted, mm</td>
<td>14.4 (3.0)</td>
</tr>
<tr>
<td>Length of Hardware</td>
<td>89.9 (53.1)</td>
</tr>
</tbody>
</table>

Weight Analysis

- Weight obtained from birth through last point of care
- Patient weights plotted
- Estimated expected growth curve
- Growth curves compared to normal males and females

All subjects weight for age

Growth curve

* Does not include premature or syndromic PRS

Airway management

<table>
<thead>
<tr>
<th>Intubation Grade</th>
<th>Airway difficulty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade I</td>
<td>MDO</td>
</tr>
<tr>
<td>Grade II/III</td>
<td>Glidescope</td>
</tr>
<tr>
<td>Grade IV</td>
<td>FOI/Glidescope</td>
</tr>
</tbody>
</table>

Conclusions

Early intervention with MDO in neonates facilitates:

- Early stabilization
- Minimal need for supportive/home care
  - Oxygen
  - Feeding
- Need for fewer invasive procedures
- Improved growth stabilization
- Airway stability
Future direction

- Further cost-based analysis comparing MDO patients to neonate patients with tracheotomy
- Long-term outcomes
- This study will be presented at the 2011 AAO-HNS Annual Meeting on September 13, 2011.
Opening the Upper Airway – Maneuvers in Pediatric Anesthesia

Thomas Erb MD, MHS
University Children’s Hospital Basel, Switzerland

Financial Disclosures

No relevant financial relationships with any commercial interests.

History

Tools
Tools
CPAP / PEEP
Mask

Risks of Airway Obstruction
- Hypoxia
- Bradycardia
- Cardiac Arrest
- Death

Keidan et al. 2000; von Ungern-Sternberg et al. 2005

Pediatric POCA Registry 1999-2004

Bhananker et al. Anesth Analg 2007 105 344

Pediatric POCA Registry 1994-2005: Children with Heart Disease

Ransamothy C et al. Anesth Analg 2010

Critical Events in Pediatric Anesthesia

Pharmacologic
Material
Diverse
Cardio-vascular
Respiration

Tay et al. 2001

Causes of Airway Obstruction
- Narrowing of pharyngeal structures
  Tonsillar- and/or adenoidal hyperplasia
  Fat tissue
  Hudgel et al. 1988, Nandi et al. 1991, Safar et al. 1959
- Reduction of dilatatory pharyngeal muscle force
  Consciousness
  Anesthetics
Location of Airway Obstruction?

- Narrowing of the Airway: Overlap of adenoids and tonsils
  - Arens et al. 2003

- Base of the tongue

3-D Reconstruction of the Upper Airway

- Healthy child
- Child with tonsillar-adenoidal hyperplasia

Effects of Anesthetic Drugs

- Posterior dislocation of the hyoid
  - Arens et al. 2005

- Backfolding of the epiglottis (inspiration)
  - Arens et al. 2005

- Most prominent narrowing:
  - Distance epiglottis/pharyngeal back-wall
  - Arens et al. 1990; Stack et al. 2003; Makena et al. 1994

- Largest diameter antero-posterior:
  - Level of the tongue
  - Arens et al. 1990; Makena et al. 1994

- Collapse of laryngeal structures
  - Reber et al. 1999
Measures?

Head- and Neck Positioning

- Sniffing position
- Cervical flexion
- Atlantooccipital extension

Optimal Angle?

- Hyperextension + flexion
- Airway resistance ↑↑
- Airway obstruction

Optimal Angle?

Body Position

- Lateral position ↔ Supine
  - Stability of the Airway ↑↑
  - Reduced folding of pharyngeal soft-tissue against posterior pharynx

Chin Lift

- Chin lift Maneuver

Stability of the Airway ↑↑

Reduced folding of pharyngeal soft-tissue against posterior pharynx


Erb, Thomas, MD, MHS

Opening the Upper Airway - Maneuvers in Pediatric Anesthesia

ISPA 6
Chin Lift

Problem: Adenoidal/Tonsillar-Hyperplasia

Chin lift may result in Airway Obstruction

Jaw thrust

1874 First description by Jacob Heiberg
1877 F. Esmarch → “Esmarch Maneuver”

Jaw thrust

Advancement of the Mandibula

→ Traction on Mn. suprahypoidii
Nandi et al 1991, Reed et al 1985

→ Enlargement of the glottic opening

→ Tidal- and Minute Volume ↑↑
Hammer et al 2001

Jaw thrust – additional uses

Evaluation of

Consciousness

Evaluation of blood pressure A. facialis

Evaluation of depth of anesthesia for LMA insertion

Aid for tracheal intubation by trainees
**Pitfalls – Jaw thrust**

Jaw thrust may aggravate or cause airway obstruction in rare cases.

**Continuous Positive Airway Pressure (CPAP)**

Upper airway under anesthesia: collapsible tube!

**CPAP**

- Cross section ↑
  - Mathew et al 1985, Reber et al 2001

- Enlargement of the retropalatal + -glossal area

- Splinting of the lateral pharyngeal wall

**moderate CPAP**

- Tidal- und Minutevolume ↑
  - Mathew et al 2001

**CPAP vs. Jaw thrust**

- Jaw thrust more effective than CPAP

- Combination of Jaw thrust / Chin lift + CPAP (5 cmH₂O)
  - Airway stability ↑↑
    - compared with Jaw thrust alone
    - but Tidal- and Minuteventilation ↓↓
  - Bruppacher et al 2003, Reber et al 2002

- CPAP with high pressures (> 15-20 cmH₂O)
  - intestinal air insufflation
  - Moynihan et al 1993

**Facemask Pressure – Gastric Insufflation**

- Regular mask handling
  - delivery of up to 100% O₂
    - CPAP / PEEP
  - Improved Oxygenation
  - Time restriction ↓
  - Functional diagnostic tool

**Endoscopy-Mask**

Regular mask handling during endoscopy
Passage of the bronchoscope through the Vocal cords – Effect on Tidal volume

\[ V_T = 44 \pm 1.5 \text{ ml} \]

\[ V_T = 20 \pm 1 \text{ ml} \]

Effect of CPAP on tidal volume during flexible bronchoscopy

\[ 0 \text{ cm H}_2\text{O} \]
\[ 5 \text{ cm H}_2\text{O} \]
\[ 10 \text{ cm H}_2\text{O} \]

\[ V_T = 20 \pm 1 \text{ ml} \]

\[ V_T = 25 \pm 1 \text{ ml} \]

\[ V_T = 25 \pm 1 \text{ ml} \]

\[ V_T = 32 \pm 1 \text{ ml} \]

Flow Time (~90 s)

Education

Tidal volume and gastric insufflation associated with different inspiratory pressure levels

\[ P = 0.0026 \]
\[ P = 0.809 \]
\[ P = 0.0059 \]
\[ P = 0.0086 \]
\[ P = 0.012 \]
\[ P < 0.0001 \]

Education and Mask Ventilation

Summary

Airway stability

Jaw thrust

Chin lift

CPAP

Additional Effect von CPAP

Finetuning essen

↑ Lateral position

↑ Sniffing position

Training in Airway Management essential

Training und Supervision
Acknowledgements

Prof. Franz Frei
Prof. Britta von Ungern-Sternberg
Prof. Adrian Reber
   Department of Pediatric Anesthesia UKBB

Prof. Jürg Hammer
   Department of Critical Care  UKBB
**EPIGLOTTIC AND BASE OF TONGUE PROLAPSE IN CHILDREN - GRADING SYSTEM AND MANAGEMENT**

Robert F. Yellon, MD  
Director of Clinical Services  
Department of Pediatric Otolaryngology  
Children’s Hospital of Pittsburgh  
Professor  
Department of Otolaryngology  
University of Pittsburgh School of Medicine

**Introduction**
- Many types of airway obstruction – excellent treatments
- Subglottic stenosis – LTR + cartilage graft
- In contrast – airway obstruction epiglottic and base of tongue (EBT) prolapse
- May be refractory to surgical treatment - tracheotomy
- Criteria for selection of patients for surgery + selection of best surgical procedure not clearly understood
- Very difficult intubation – special techniques

**EBT Prolapse**
- Not the same as laryngomalacia
- Classical laryngomalacia – omega shaped epiglottis, short AE folds + floppy arytenoids
- Collapse into airway on inspiration
- When surgical correction required
- Supraglottoplasty with lysis of AE folds corrects problem
- Lysis of the AE folds will not correct EBT prolapse

**Pediatric Pharyngeal + Supraglottic Airway Obstruction**
- No classification system exists for pediatric population
- Other devised systems for pharyngeal airway obstruction – adults
- Stanford group (Li, Riley, Powell 1993)
- Type 1 obstruction – retropalatal
- Type 2 obstruction – both retropalatal and retrolingual
- Type 3 - retrolingual
Pediatric Pharyngeal + Supraglottic Airway Obstruction
- Proposed pediatric system (Yellon) Laryngoscope 2006
- Severity can range from normal to complete obstruction by base of tongue with no epiglottis visible
- Position of epiglottis is noted in addition to position of base of tongue
- Addresses both severity and anatomic sites of obstruction
- May provide more precise system for comparisons before and after surgery, between patients + between surgeons

Pediatric Pharyngeal + Supraglottic Airway Obstruction
- Froehlich and colleagues – Discoordinate Pharyngolaryngomalacia
- 27 children – severe laryngomalacia
- Absence short AE folds/redundant supraglottic mucosa
- Supraglottic and pharyngeal collapse on inspiration
- Glossoptosis 41%
- 16/27 children– supraglottoplasty– none cured
- Some resemblance to EBT prolapse

EBT Prolapse in Children
- Interest in challenging entity of EBT prolapse
- Occurred because these children often require tracheotomy or have “difficult airway”
- Airway obstruction may persist despite various attempts at surgical therapy
- Very difficult intubation

Primary EBT Prolapse
- Occurs in absence of mandibular hypoplasia
- Persists following correction of mandibular hypoplasia
- Cause not clearly defined
- Possible etiologies
- Anatomic factors
- Localized hypotonia
- Poor neuromuscular control of upper airway structures

Primary EBT Prolapse
- More difficult problem than EBT prolapse secondary to mandibular hypoplasia
- Mandibular advancement is not always successful + not always an option if mandible is not hypoplastic

Secondary EBT Prolapse
- Familiar to all pediatric airway specialists
- Main cause is mandibular hypoplasia
- Robin sequence, Treacher Collins, Nager syndromes
- Small mandible– inadequate space- both tongue + airway
- Glossoptosis (grade 3) and airway obstruction at EBT levels
- Correction of mandibular hypoplasia may correct EBT prolapse
**Diagnosis EBT Prolapse**

- Usually made during flexible fiberoptic laryngoscopy
- Spontaneous ventilation – lightly sedated
- Dynamic airway assessment
- Other useful modalities –
  - Flexible fiberoptic laryngoscopy while asleep
  - Polysomnography (capped trach)
  - Three-dimensional airway computed tomography
  - Airway magnetic resonance imaging sedated

**Differential Diagnosis**

BOT multiple pathologies- airway obstruction
- Lingual tonsil hypertrophy +
- Thyroglossal duct cyst (Munson 2007)
- Macroglossia
- Lingual thyroid
- Lymphatic vascular malformations
- Lymphoma
- Transplant PTLD

**EBT Prolapse**

BOT multiple pathologies- airway obstruction
- Lingual tonsil hypertrophy
- Fricke + Schott 2006
- OSA persisted after T+A
- Sedated MRI
- Increased size lingual tonsils OSA+Downs

**EBT Prolapse**

BOT- airway obstruction
- Airway size
- Sedated CT
- AHI inversely correlated with retropalatal and retrolingual airway minimal cross-sectional area
- Heo + Kim 2011
EBT Prolapse

BOT- airway obstruction
- Pharmacologic effects
- Airway size 9 infants
- MRI
- Propofol dose dependant
- Decreased airway caliber
- Corrected with CPAP Mask Ventilation
- Crawford 2006

Definition of EBT Prolapse and Proposed Grading System
Laryngoscope February 2006

- Grade 0 – normal airway
- Grade 1 – prolapse of epiglottis against posterior pharyngeal wall
- Obstruction airway but normal position – base of tongue
- Different entity than classical laryngomalacia

Definition of EBT Prolapse and Proposed Grading System

- Grade 2 – prolapse of epiglottis and base of tongue
- Only the tip of the epiglottis visible + obliteration of the vallecula
Definition of EBT Prolapse and Proposed Grading System

- Grade 3 – complete prolapse of tongue against posterior pharyngeal wall
- No portion of the epiglottis visible (glossoptosis)

Results

Other Surgeries
- Distraction osteogenesis of mandible (n=3, 21%)
- Hyoid advancement (n=3, 21%)
- Slide genioplasty (n=1, 7%)
- Supraglottotomy (n=1, 7%)
- Lysis of scar bands from epiglottis to pharynx (n=1, 7%)
- Reversal of laryngotracheal separation (n=1, 7%)
- Laryngotracheal reconstruction with rib graft (n=1, 7%)
- Supraglottoplasty (n=1, 7%)
- Tonsillectomy/adenoidectomy (n=2, 14%)
- Complete airway evaluation + multiple surgeries common
Results GERD
- 9 of 14 (64%) positive tests for GERD
- 13 of 14 (93%) GERD therapy
- 8 of 14 (57%) pharmacologic therapy
- 5 (36%) fundoplication

Results Swallowing Dysfunction
- 5 (36%) swallowing dysfunction – modified barium swallow (MBS)
- 2 (14%) aspiration, 3 (21%) penetration without aspiration
- 8 (57%) normal swallowing function – MBS or salivagram
- 1 (7%) no clinical evidence – swallowing dysfunction - negative BAL, no other tests

Results Genetic Syndromes
- 5 (36%) children had defined genetic syndromes
  - Nager, Goldenhar, DiGeorge, Achondroplasia, Larsens
- 1 (7%) child had Robin sequence

Intubation for EBT Prolapse
- Difficult Laryngoscopy and Intubation
- Laryngoscopy scoop maneuver
- Cricoid pressure – place ETT with stylette anterior to arytenoids
- Lift epiglottis with laryngoscope
- Fiberoptic intubation
- Fiberoptic intubation through LMA (Asai 2008)
- Be prepared to lift epiglottis with scope

Intubation for EBT Prolapse
- Two Person Technique
- Yellon + Borland ASPO
- Fiberoptic Intubation Ped Bronchoscope
- Curved malleable retractor
- Elevate tongue and epiglottis
- Expose glottic airway
- Second person passes bronch into trachea
- Place ETT over bronchoscope
Surgical Therapy for EBT Prolapse

- Swallowing dysfunction 5/14 (36%) children – EBT prolapse
- Precludes aggressive surgical therapy
- May cause aspiration
- Use CPAP, tracheotomy or leave tracheotomy
- Rather than perform relatively risky surgery
- Argue – safest treatment – CPAP or tracheotomy – outgrow
- Natural history EBT prolapse – not described

EBT Prolapse in Children

Two year follow up outcomes study
- 14 children EBT Prolapse
- 5/14 (36%) decannulated
- 4/5 (80%) decannulated had surgery
- 1 spontaneous resolution (13 year old)
- 8/9 (89%) that were not decannulated – developmental delay/hypotonia
- Developmental delay/hypotonia leave trach in

Yellon, Robert, MD  Epiglottic and Base of Tongue Prolapse in Children - Grading System and Management
Surgical Therapy for EBT Prolapse

Surgical options
- Tracheotomy
- Mandibular advancement
- Mandibular and maxillary advancement
- Hyoid advancement
- Genial tubercle advancement for older child or adult
- Epiglottoplasty + epiglottopexy
- Tongue base sling procedures – sutures or fascia
- BOT reduction- electrocautery, coblation or radiofrequency ablation
- SMILE procedure

Surgical Therapy for EBT Prolapse

Surgical options
- Multiple options indicates single approach may not be effective
- Wise to tell parents that multiple procedures may be necessary

Nonsurgical Therapy for EBT Prolapse

- Continuous positive airway pressure (CPAP) – risk free trial – always considered as first-line treatment
- Decreased apnea/hypopnea index – OSA
- Device not tolerated, or noncompliant with regular use
- Children less likely to tolerate CPAP than adults
- One month acclimatization period
- Successful CPAP series in pediatric population – reported
- CPAP test readiness for trach decan – trach capped

Surgical Therapy for EBT Prolapse

Surgical options
- Tracheotomy
- Most conservative
- Little risk of aspiration

Surgical Therapy for EBT Prolapse

Surgical options
- Hyoid advancement
- Multiple heavy sutures
- Theorhetically reversible

Surgical Therapy for EBT Prolapse

Surgical options
- Mandibular advancement short jaw
- Ow 2008 meta analysis adults and children
- 178 articles- 1185 cases
- 91% effective
- Mandell, Yellon 2004 poor results neuro delayed
- Mandibular and maxillary advancement (bimaxillary advancement) Adults
- Li Powell Stanford 75% success (50% red. AHI)
EBT Prolapse

Surgical options
- Genial tubercle (genioglossus) advancement for older child or adult
- Can also perform after mandibular advancement as secondary procedure
- Useful for Treacher-Collins and Nager
- Heller + Bradley 2006

EBT Prolapse

Surgical options
- Epiglottoplasty + epiglottopexy

EBT Prolapse

Surgical options
- Tongue base sling procedures – sutures or fascia
- C. Bower Personal Communication 50% success
EBT Prolapse
Surgical options
• BOT reduction-
  • Electrocautery
  • Coblation
  • Radiofrequency ablation

EBT Prolapse
Surgical options
• BOT reduction-
  • Electrocautery
  Can combine with epiglottopexy if prolapse

EBT Prolapse
Surgical options
• BOT reduction-
  • Coblation
  • Good tissue reduction
  • Less pain

EBT Prolapse
Surgical options
• SMILE procedure
• Maturu + Mair 2006
• Mucosal incision and tongue muscle ablation using coblator
• Possibly less pain with coblator and submucosal resection

EBT Prolapse
Surgical options
• BOT reduction-Adults
  • Radiofrequency ablation multiple treatments
  • Associated with abscesses
  • Roteberg Laryngoscope 2011 – endoscopic
  • Wooten, Shott 2010 – Pediatric-combine with genioglossus advancement 61% success

EBT Prolapse Conclusions
• Diagnosis flexible endoscopy spontaneous ventilation
• PSG, Sedated CT
• GERD + aspiration common
• Use CPAP if possible – assess capped trach for decan
• Tracheotomy
• Some children outgrow with time
• Surgery if no aspiration or hypotonia
• Multiple surgeries common
• Special planning for intubation-fiberoptic, LMA, Two-Person Technique
Dexmedetomidine
Pediatric airway management

James Gordon Cain, M.D., F.A.A.P.
Past President, International Trauma Anesthesia and Critical Care Society
Past President, West Virginia State Society of Anesthesiologists
Director, Perioperative Medical Services, Children’s Hospital of Pittsburgh of UPMC
Director, Trauma Anesthesiology, Children’s Hospital of Pittsburgh of UPMC
Visiting Associate Professor, University of Pittsburgh

Disclosures

- Drug Safety Monitoring Board
- Hospira
- Off label uses will be discussed
  - No labeled uses for pediatrics!

**WARNING**
No children allowed in this area

Dexmedetomidine labeled prescribing

- **Indications**
  - Sedation of initially intubated and mechanically ventilated patients during treatment in the ICU
  - Consider 1 mcg/kg loading dose
  - 0.3-0.7 mcg/kg/hour

- **Contraindications**
  - Caution in patients with advanced heart block

- **Drug Interactions**
  - Vagal effects can be counteracted by IV administration of anticholinergic agents

- **Disease Affecting Clearance**
  - Clearance is lower in patients with hepatic impairment

Precedex® [package insert]
15 year old for palatoplasty

Past medical history
- Cleft palate
- S/P primary repair
- Retrognathia
- Syringomyelocele
- S/P Chiari repair
- Scoliosis
- S/P cervical anterior/posterior fusion

Anesthesiology history
- No airway difficulty prior to Chiari repair & A/P fusion
- Difficult intubation last year
- Unable to intubate last month
- Syringomyelocele
- S/P Chiari repair
- Scoliosis
- S/P cervical anterior/posterior fusion

Difficult intubation last year
- Moderate mask
- Unable to intubate with DL
- LMA 4 placed
- FOB intubation via LMA

Unable to intubate last month
- Moderate mask
- Glidescope no view
- LMA 4 poor fit, no view
- LMA 3 placed
  - FOB to trachea
  - FOB accidentally removed while ETT advanced
  - Unable to re-obtain view
- Failed FOB without LMA assistance
- Palatoplasty postponed
Returns for palatoplasty

- Oral intubation required for surgery
- Awake, sedated intubation?
- Trach?
- Goals
  - Hemodynamic stability
  - Respiratory stability
  - Post operative safety
  - Patient cooperation
  - Patient comfort

Achieving Optimal Patient Comfort

The Fine Balance in Patient Comfort
The Fine Balance in Patient Comfort

Unable to perform task
Anxiety
Agitation
Hypertension
Tachycardia
Wound disruption
Patient injury

The Fine Balance in Patient Comfort

Airway obstruction
Hypoventilation
Hypotension
Delayed emergence
Delayed weaning
Increased cost

How would you proceed?
Airway management plan

- Awake FOB with sedated trach as backup
- PIV placed
- Standard monitors
- Lidocaine nebulized
- Glycopyrrolate 0.4 mg IV
- Scopalamine 0.4 mg IV
- Droperidol 1.25 mg IV
- Are there additional options?

What next?

Considerations

- What is the underlying process requiring treatment?
- Does the drug/technique rectify, ignore or exacerbate the underlying process?
\[ \alpha_2 \] Agonists: Chemical Structures

\[ \begin{align*}
\text{Clonidine} & : \begin{array}{c}
\text{Cl} \\
\text{Cl} \\
\text{H} \\
\text{N} \\
\end{array} \\
\text{Dexmedetomidine} & : \begin{array}{c}
\text{H} \\
\text{N} \\
\text{CH}_3 \\
\text{CH}_3 \\
\end{array}
\end{align*} \]

\[ \alpha_2 \] Agonists

\[ \begin{align*}
\text{Clonidine} & : \\
\text{Selectivity: } \alpha_2/\alpha_1 & : 200:1^1 \\
\text{t}^{1/2} & : 10 \text{ hrs}^1 \\
\text{PO, patch, epidural} & : ^2 \\
\text{Antihypertensive} & : ^1 \\
\text{Analgesic adjunct} & : ^1 \\
\text{IV formulation not available in US} & : ^1 \\
\text{Dexmedetomidine} & : \\
\text{Selectivity: } \alpha_2/\alpha_1 & : 1620:1^3 \\
\text{t}^{1/2} & : 2 \text{ hrs}^3 \\
\text{Intravenous} & : ^3 \\
\text{Sedative-analgesic} & : ^3 \\
\text{Primary sedative} & : \\
\text{Only IV } \alpha_2 \text{ available for use in the US} & : ^3
\end{align*} \]

\[ \alpha_2 \] Receptor Subtypes

**α₂ Agonists:**

**Pharmacodynamics**

- Sedation/hypnosis
- Anxiolysis
- Analgesia
- Sympatholysis (decrease BP, HR, NE)
- Reduces shivering
- Neuroprotective effects
- No effect on ICP
- No respiratory depression

---

**Mechanism for α₂-Induced Sedation/ Hypnosis in the Rat Locus Ceruleus**

---

**Arousalability From Sedation During Dexmedetomidine Infusion**

![Graph showing BIS levels during placebo and dexmedetomidine infusions.](image)
**Analgesic Effect**

<table>
<thead>
<tr>
<th></th>
<th>Opioids</th>
<th>α₂-Agonists</th>
</tr>
</thead>
<tbody>
<tr>
<td>Periphery</td>
<td>Inhibit inflammation</td>
<td>Inhibit sympathetic-mediated pain</td>
</tr>
<tr>
<td>Afferent Primary</td>
<td>Inhibit release of SP and glutamate</td>
<td>Inhibit release of SP and glutamate</td>
</tr>
<tr>
<td>Neurons</td>
<td>Inhibit firing</td>
<td>Inhibit firing</td>
</tr>
<tr>
<td>Subcortical</td>
<td>Decrease emotive aspects</td>
<td>Decrease emotive aspects</td>
</tr>
<tr>
<td>Dorsal</td>
<td>Activate peri-aqueductal gray;</td>
<td>Disinhibit A5/A7 noradrenergic pathways</td>
</tr>
<tr>
<td>inhibitory pathways</td>
<td>Activate noradrenergic pathways</td>
<td></td>
</tr>
</tbody>
</table>

**Dexmedetomidine spares opioids**


**Cardiorespiratory and Neural**

<table>
<thead>
<tr>
<th>Agent</th>
<th>BP</th>
<th>HR</th>
<th>Cerebral Protection</th>
<th>Respiration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Opioids¹</td>
<td>↓</td>
<td>↓</td>
<td>↑</td>
<td>↓↓↓↓</td>
</tr>
<tr>
<td>Benzodiazepines</td>
<td>↓</td>
<td>↓</td>
<td>↑</td>
<td></td>
</tr>
<tr>
<td>Propofol¹</td>
<td>↓↓</td>
<td>↓</td>
<td>↑↑</td>
<td>↓↓↓</td>
</tr>
<tr>
<td>Dexmedetomidine²</td>
<td>↓↓</td>
<td>↓</td>
<td>↑</td>
<td></td>
</tr>
<tr>
<td>Haloperidol³</td>
<td>↓</td>
<td>↓</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

Dexmedetomidine for airway anesthesiology

- Critical airway with local anesthetic allergy\(^1\)
- Difficult airway due to odontogenic infections\(^2\)
- Awake trach\(^3\)
- Anterior mediastinal mass\(^4\)
- No respiratory depression\(^5\)


Dexmedetomidine for pediatric anesthesiology

- Enhances post op T&A comfort\(^1\)
- Enhances post op LTR sedation\(^2\)
- No significant effect on upper airway morphology\(^3,4\)
- Beats propofol for OSA spontaneous ventilation\(^5\)
- Well tolerated, predictable hemodynamics with bolus\(^6\)
- No effect on ECG\(^7\)


Clinical Strategies

- What are the goals of sedation and analgesia?
- Can existing drugs achieve these goals:
  - Alone or in combination?
  - By bolus or infusion?
- Is there an unmet need?
  - Can dexmedetomidine fill it?
- Clinical challenges:
  - What are they and how can we meet them?
Choosing the Right Drug

Sedation

Anesthesia  Hypnosis  Anxiolysis

Patient Comfort

Sedation

Anesthesia  Hypnosis  Anxiolysis

Benzodiazepines
Sedation

Amnesia  Hypnosis  Anxiolysis

OPIOIDS

Sedation

Amnesia  Hypnosis  Anxiolysis

LOCAL ANESTHESIA

Where Dexmedetomidine Fits In

Cain, James G. MD, FAAP
Dexmedetomidine

ISPA 6
**Sedation**

- **Primary**
  - Dexmedetomidine
- **Adjunct Analgesia**
  - Local Anesthesia

**Awake sedated intubation**

- Dexmedetomidine IV
  - 2 mcg/kg/hour
- Cooperative, comfortable patient
- Hemodynamically stable
- No respiratory depression
- Intubated
- Induced with propofol

**Peri-operative Infusion Strategy**

- Assess volume status of patient
  - Hypovolemic
  - Euvolemic
- Monitor BP/HR throughout
- If bradycardia, consider atropine

- Dex loading dose: 0.5-2 mcg/kg/hour infusion for 10 minutes
- Initial target: 0.5 mcg/kg/hr, may increase based on effect
- Adjust infusion accordingly
- Dex continuous infusion: 0.5 to 2 mcg/kg/hr

Dex = dexmedetomidine.
**Dexmedetomidine based balanced anesthetic**

- Dexmedetomidine 0.5-2 mcg/kg/HOUR
- Volatile anesthesia
- Desflurane
- Non-depolarizing neuromuscular blockade
  - Maintain TOF ¼
  - Block by surgeon

**Sedation**

- Amnesia
- Hypnosis
- Anxiolysis
- Volatile Agents
Dexmedetomidine based balanced anesthetic

+ 

Emergence and post op
- Neuromuscular blockade reversed
- D/C volatile agent
- D/C dexmedetomidine
- Delayed emergence
  - Physostigmine (antilirium) given
  - Immediate emergence with follow commands
- Extubated over tube changer
- Patient monitored in OR
- Transported to ICU
- No recall of intubation

Cases where dexmedetomidine may be useful.
- Airway management
- Bariatric surgery
- Breast Reduction
- Cardiac
- ICU
- Neuro
  - Spine
  - Crani
  - Awake
- Off-site
- Ophthalmology
- Ortho
- Pediatrics
- Thoracic
- Trauma
- Vascular
  - AAA
  - Carotid
  - Peripheral
### Dexmedetomidine

#### Advantages
- Sedative, analgesic, and anxiolytic\(^1\)
- Respiratory stability\(^2\)
- Predictable hemodynamics\(^1\)
- Arousable and oriented\(^3\)
- No need to discontinue before extubation\(^4\)
- Antishivering\(^5\)
- Decreases emergence delirium

#### Limitations
- May reduce HR and BP (caution in hypovolemia, shock, and heart block)\(^6\)
- Potentiates effects of opioids, sedatives and anesthetics\(^4\)
- Dry mouth\(^4\)
- Vasoconstriction at high dose\(^6\)

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### Questions?
Effect of Dexmedetomidine and Propofol Anesthesia on Upper Airway in Children

Mohamed Mahmoud MD
Cincinnati Children’s Hospital Medical Center

Financial Disclosures

- No relevant financial relationships with any commercial interests.

MRI Sleep Study

Indications:
Persistent OSA despite previous surgery, multilevel obstruction
(Down syndrome)

Airway evaluation:
Static and dynamic images
Causes of persistent obstructive sleep apnea despite previous T&A in children with Down syndrome as depicted on static and dynamic cine MRI
Donnelly, Shott, LaRose, Chini, Amin. Am J Roentgenol 2004

27 patients – Mean age 9.9 years
- Macroglossia 74%
- Glossoptosis 63%
- Recurrent adenoids 63%
- Enlarged lingual tonsils 30%
- Hypopharyngeal collapse 22%

Glossoptosis
- 7-year-old boy with persistent obstructive sleep apnea despite previous tonsillectomy and adenoidectomy

Hypopharyngeal collapse
OSA – Surgical options for base of tongue obstruction

- Lingual tonsillectomy
- Radiofrequency reduction to base of tongue
- Genio-glossus advancement
- Resection of wedge of base of tongue
- Coblation: Midline posterior glossectomy
- Mandibular advancement

Case:
- A 3-year-old, 16.4 kg
- History of obstructive sleep apnea, S/P T&A cleft lip and palate repair
- Polysomnography showed:

  96 episodes of obstructive apnea (lowest O2 saturation 71%, average duration 12.8 seconds and longest 45.5 seconds)

Optimal MRI Sleep Study

- Spontaneous breathing
- No artificial airway
- Identify anatomic causes of airway obstruction
Why Optimal Study is Anesthesia Challenge?

- Significant oxygen desaturation
- Airway intervention is a problem!

Nasal airway intervention

Oral airway intervention
Ketamine and Dexmedetomidine for MRI Sleep Studies

- Sedation initiated with a bolus dose of ketamine (1 mg/kg) and dexmedetomidine (1 mcg/kg)
- Continuous infusion of dexmedetomidine (1 mcg/kg/h)

Luscri et al. Pediatric Anesthesia 2006 16: 782–786

Ketamine and Dexmedetomidine for MRI Sleep Studies

Dexmedetomidine prevents:
- Tachycardia
- Hypertension
- Salivation
- Emergence phenomena

Ketamine prevents:
- Bradycardia
- Hypotension

Dexmedetomidine VS Propofol for MRI Sleep Studies

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Dexmedetomidine</th>
<th>Propofol</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Obstructive Index (events/hour)</td>
<td>2.7 ± 1.9</td>
<td>3.1 ± 1.3</td>
<td>0.53 †</td>
</tr>
<tr>
<td>Respiratory Disturbance Index (events/hour)</td>
<td>3.6 ± 1.9</td>
<td>4.4 ± 1.7</td>
<td>0.30 †</td>
</tr>
</tbody>
</table>

Mild

| Needed Artificial Airway, N (%) | 2 (13) | 1 (13) | 1 ‡ |

| Obstructive Index (events/hour) | 10.2 ± 5.8 | 8.8 ± 3.8 | 0.54 † |
| Respiratory Disturbance Index (events/hour) | 11.0 ± 5.8 | 10.9 ± 4.3 | 0.96 † |

Moderate

| Needed Artificial Airway, N (%) | 2 (18) | 3 (33) | 0.62 ‡ |

| Obstructive Index (events/hour) | 21.8 ± 11.3 | 23.6 ± 13.5 | 0.74 † |
| Respiratory Disturbance Index (events/hour) | 23.8 ± 11.2 | 24.9 ± 13.1 | 0.83 † |

Severe

| Needed Artificial Airway, N (%) | 1 (7) | 5 (56) | 0.02 ‡ |

Are there qualitative differences in the hypnotic response produced by DEX

- Provides sedation without significant respiratory depression
- Sedative properties that parallel natural sleep

Hypnotic response produced by DEX

Pharyngeal dilator muscle activation

Effect of increasing depth of dexmedetomidine anesthesia on upper airway morphology in children

- Purpose: To prospectively determine changes in the size of the upper airway in children with high versus low dose of DEX using cine MRI
**Methods**

- MRI of brain for clinical reasons (3-10 year old)
- Exclusion criteria: severe co-morbidity (ASA > 2), history of OSA or snoring, airway or craniofacial abnormality, obesity, developmental delay, or DEX allergy
- IV placed with O2/N20
- Depth of sedation was assessed with UMSS

**Study Design**

Low DEX
1 mcg/kg/h

High DEX
3 mcg/kg/h

Research Images

Diagnostic Brain

Research Images

**Research Images**

- **SSFSE (single shot fast spin echo)**
  - Axial
  - base of the tongue
  - 5 seconds

- **Fast Gradient Image (Cine)**
  - Sagittal midline
  - soft palate, base of the tongue
  - 2 minutes
**Static Measurements**
- Axial SSFSE
- Retroglossal Area
- AP diameter
- Trans diameter

**Dynamic Measurements**
- FGE Cine
- NP Area
- NP diameter
- RG Area
- RG diameter
- Min/Max

**Automated Volume Segmentation Analysis - Cine**
Automated Volume Segmentation Analysis

- Nasopharyngeal airway
  - Mean upper airway value
  - Mean lower airway value
  - Mean difference (collapsibility)
- Retroglossal airway
  - Mean upper airway value
  - Mean lower airway value
  - Mean difference (collapsibility)

Results

- N = 23
- Mean age 5.95 ± 1.82 years
- Male : Female 12 : 11
- No patients showed clinical signs of airway obstruction at Low or High dose DEX
- No hemodynamic instability

Axial Static SSFSE Images Retroglossal Airway

<table>
<thead>
<tr>
<th></th>
<th>Mean (Low DEX)</th>
<th>Mean (High DEX)</th>
<th>Mean of differences (95% CI)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>AP Diameter (mm)</td>
<td>8.63</td>
<td>8.18</td>
<td>0.46 (-0.23, 1.16)</td>
<td>0.18</td>
</tr>
<tr>
<td>Transverse Diameter (mm)</td>
<td>9.78</td>
<td>8.95</td>
<td>0.33 (-0.31, 1.00)</td>
<td>0.79</td>
</tr>
<tr>
<td>Area (mm²)</td>
<td>62.59</td>
<td>59.89</td>
<td>2.70 (-4.88, 10.28)</td>
<td>0.47</td>
</tr>
</tbody>
</table>
Dynamic Measurements
Sagittal Cine Images - Manual

<table>
<thead>
<tr>
<th>Nasopharyngeal Sagittal Cine Image</th>
<th>Mean (mm)</th>
<th>Mean of Difference (95% CI)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>AP Diameter</td>
<td>Low</td>
<td>High</td>
<td></td>
</tr>
<tr>
<td>Maximum</td>
<td>5.67</td>
<td>5.67</td>
<td>0.09</td>
</tr>
<tr>
<td>Minimum</td>
<td>4.69</td>
<td>4.67</td>
<td>0.08</td>
</tr>
<tr>
<td>Area (mm²)</td>
<td>Low</td>
<td>High</td>
<td></td>
</tr>
<tr>
<td>Maximum</td>
<td>254.64</td>
<td>274.27</td>
<td>0.005</td>
</tr>
<tr>
<td>Minimum</td>
<td>209.75</td>
<td>206.06</td>
<td>0.002</td>
</tr>
</tbody>
</table>

Retropharyngeal Sagittal Cine Image

<table>
<thead>
<tr>
<th>AP Diameter</th>
<th>Mean (mm)</th>
<th>Mean of Difference (95% CI)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>7.05</td>
<td>6.54</td>
<td>0.002</td>
</tr>
<tr>
<td>High</td>
<td>8.37</td>
<td>8.57</td>
<td>1.15</td>
</tr>
</tbody>
</table>

INSPIRATORY

**A.** Sagittal Nasoaevalvular Cross-Sectional Area

**B.** Sagittal Nasoaevalvular Cross-Sectional Area

**C.** Sagittal Retropharyngeal Cross-Sectional Area

**D.** Sagittal Retropharyngeal Cross-Sectional Area

EXPIRATORY

**A.** Sagittal Nasoaevalvular Anteroposterior

**B.** Sagittal Nasoaevalvular Anteroposterior

**C.** Sagittal Retropharyngeal Anteroposterior

**D.** Sagittal Retropharyngeal Anteroposterior
Dynamic Measurements
Automated Volume
Segmentation Analysis

<table>
<thead>
<tr>
<th>Collapsibility (Mean area change)</th>
<th>Mean of Differences (90% CI)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nasopharyngeal Airway</td>
<td>0.16</td>
<td>0.11</td>
</tr>
<tr>
<td>Retroglossal Airway</td>
<td>0.29</td>
<td>0.82</td>
</tr>
</tbody>
</table>

Effect of Increasing Depth of Dexmedetomidine and Propofol on Upper Airway Morphology in Children with a History of Obstructive Sleep Apnea

- Changes in the size of the upper airway in children with OSA
- Defined criteria for airway intervention

Effect of Increasing Depth of Propofol Anesthesia on Upper Airway Configuration in Children

- 15 children aged 2–6 yr
- Propofol dose range 50 - 240 mcg/kg/m
- A respiratory bellows was placed around the chest to obtain a waveform of the respiratory cycle
Airway values at expiration

Airway values at inspiration

Where is the narrowest portion of the airway?
- 9 infants
- Propofol dose range 50 - 240 mcg/kg/m
- Hypothesis: Airway narrowing with increasing depth of propofol anesthesia is greater in infants

Upper airway collapsibility was determined at three concentrations of propofol Anesthesia (2.5, 4.0, and 6.0 mcg/ml)

- Profound inhibition of genioglossus muscle activity
Airway Catastrophe

- Mild enlargement of the lingual tonsils

DEX/Ketamine for Airway Catastrophe

Dexmedetomidine and ketamine for large anterior mediastinal mass biopsy
Conclusions

- DEX effect on airway appears to be benign

- All precautions to manage airway obstruction should be taken when DEX is used for sedation
Sedation for Pediatric Videolaryngostroboscopy
It’s not just about the drugs…
Timing really is everything…
And
They aren’t just small adults…
Joseph E. Dohar, M.D., M.S.
Lawrence M. Borland, MD

It’s All About the Picture
- Visualization of the larynx for diagnosis became standard over 100 years ago
- Garcia’s invention, the laryngeal mirror, started the quest to devise better methods

DEFINITION
- Valuable diagnostic modality currently used successfully in the adult population to offer diagnostic information regarding laryngeal disorders and voice abnormalities
- Widely used in adults but its use in pediatrics is limited because of the inability of many children to tolerate the procedure

Advantages of Videolaryngostroboscopy
- Mortensen *et al.* published a retrospective series of 80 pediatric videostroboscopy patients
- All previously examined by flexible laryngoscopy and treated with speech therapy for presumed vocal cord nodules
- The authors concluded that children with a history of prolonged dysphonia for whom treatment has failed should be referred for evaluation by videolaryngostroboscopy

Advantages of Videolaryngostroboscopy
- Its value includes elucidation of subtle features of different disease processes
- Clarification of the differences between benign mucosal disorders that might require surgical intervention
- Assistance in identifying inflammatory processes that contribute to dysphonia

Advantages of Videolaryngostroboscopy
- The only validated grading scale for pediatric vocal fold nodules is based on a transnasal videolaryngostroboscopic examination
- For the standard of pediatric voice care to approximate that in adults, some alternative means of performing videolaryngostroboscopy is needed in children uncooperative for such an assessment in an office setting
- Despite great effort in our voice center to familiarize and desensitize children to the equipment and procedure, some children are, nonetheless, unable to tolerate even a brief examination

Shaw TVC Nodule Grading Scale
- Grade of 0 Normal/comlete adduction with smooth vocal fold contour (i.e. no nodule present)
- Grade 1 Normal complete adduction with a small nodule located on the vibratory edge protruding less than 0.5 mm
- Grade 2 nodules may be associated with an anterior glottic chink on adduction with a moderate sized nodule protruding > 0.5-1.0 mm
- Grade 3 nodules associated with an “hourglass” configuration of aperture closure on adduction with a large nodule protruding >1.0 mm on the vibratory edge
- The nodule was described as
  - Discrete by the subscript “D” when the base of the nodule was no more than twice the width or sessile
  - Sessile by the subscript “S”, where a broad base exceeded twice the width of the nodule

*Otolaryngology - Head & Neck Surgery.* 136(2) 2007: 193-7

**Shaw TVC Nodule Grading Scale**
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*Otolaryngology - Head & Neck Surgery.* 136(2) 2007: 193-7

**The Challenge: How We (Larry) Do It**
- Midazolam (0.5mg/kg po or 0.2mg/kg intranasal) was given 20-30 minutes before transport to the endoscopy suite
- Nitrous oxide (70%)/oxygen (30%) mixture was administered by mask to facilitate intravenous cannula insertion
- Meperidine was then administered intravenously in increments (total dose: range 0.4 - 1.75 mg/kg)
- For teenagers and young adults, Fentanyl (total dose 100 mcg) was substituted for meperidine

**How We (Larry) Do It**
- Oxymetazoline was administered as a topical nasal decongestant and 1% lidocaine for topical anesthesia
- Propofol was administered, initially in bolus increments (total dose: range 0.42- 2.63 mg/kg)
- Because of pain at the site of injection, the mode of administration was switched to a constant infusion (35-50 mcg/kg/min)
- Lidocaine (1%) was applied to the larynx.

**Outcomes**
- Mean age was 6 years (SD 3.7 years; range: 2 to 14 years)
- 90% success rate defined as toleration of procedure with significant phonation time make diagnosis
- No complications
- None required further testing
**Key Stroboscopic Distinguishing Features**

- Glottal Closure*
- VF Amplitude-1/3 width
- Vibration*
- Phase Closure*-1/2 modal Fº
- Roughness of VC Edge*
- Mucosal Wave
- Periodicity
- Phase Symmetry*
- TVC Vertical Height
  - *most important for Dx
  - *most important for Rx

**How Does Videolaryngostroboscopy Help?**

- Nodules
  - No mucosal wave disturbance
  - Abnormal glottic aperture closure
- Cysts
  - Diminished mucosal wave
    - Marked-submucosal (epidermoid inclusion)
    - Minimal-subepithelial (mucous retention)
- Polyps
  - No to minimal mucosal wave disturbance
  - Superior/Inferior mucosal edge
- Papillomas
- Reactive Lesions
- Edema

**Help Assess Function?**

- Unilateral paralysis usually able to be confirmed
- Bilateral paralysis often able to be confirmed and may obviate the need for laryngeal EMG also a challenge in children
- Mucosal wave often appears “increased” in paralysis due to flaccidity
- Wave travels “faster” and traversed greater distance on normal cord
- May decrease in old RLN injury after vocalis muscle atrophy reduces tone and leaves it as flaccid as its cover
- Vertical height of paralyzed displaced inferiorly
- Remember stroboscopy does not assess abduction and adduction but rather vocal fold vibration!
- Phase asymmetry with longer open vs. closed phase
- Onset of improvement seen earlier-w/greater accuracy

**How Does Videolaryngostroboscopy Help in Surgery**

- The goal of microlaryngeal surgery is to treat the pathology while preserving or improving vocal function. Aspirate before injection and avoid maximal dose at first treatment
- Patients whose stroboscopic examination implies lack of involvement of the vocal ligament are candidates for medial microflap technique
• The medial microflap technique was thus developed (cysts, polyps)
• An incision is made over or abutting the lesion, which is then dissected from the vocal ligament and overlying mucosa
• Lateral microflap technique enables better identification of vocal ligament and lowers the risk of its injury, particularly when scars and tightly adherent lesions are present (i.e. adynamic segment suggesting abnormal lamina propria)

**Kids are Just Not Little Adults**
• The infant lamina propria is composed of only one layer, as compared to three in the adult, and there is no vocal ligament
• The vocal ligament begins to be present in children at about four years of age
• Two layers appear in the lamina propria between the ages of six and twelve
• The mature lamina propria, with the superficial, intermediate and deep layers, is only present by the conclusion of adolescence
• Puberty usually lasts from 2–5 years, and typically occurs between the ages of 12 to 17 years
• The free edge of the vibratory portion of the vocal fold, the anterior glottis, is covered with stratified squamous epithelium
• The posterior glottis is covered with pseudostratified ciliated epithelium
• As vocal fold vibration is a foundation for vocal formants, this presence or absence of tissue layers influences a difference in the number of formants between the adult and pediatric populations
• In females, the voice is three tones lower than the child’s and has five to twelve formants, as opposed to the pediatric voice with three to six
• The length of the vocal fold at birth is approximately six to eight millimeters and grows to its adult length of eight to sixteen millimeters by adolescence
• The infant vocal fold is half membranous or anterior glottis, and half cartilaginous or posterior glottis
• The adult fold is approximately three-fifths membranous and two-fifths cartilaginous

**How Else Does it Help in Pediatric Voice**
• SGS
• Most challenging voice cases in pediatrics
• Prolonged intubation compromises voice
• LTR compromises voice
• Compensatory vocal strategies compromise voice
• At present, focus is on improving aperture closure