Anesthesia Considerations for Dynamic Upper Airway Evaluation

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Objectives

• Diagnosis of Sleep Disordered Breathing

• Anesthetic Challenges for Upper Airway Evaluation

• Upper Airway and Anesthesia

• Applications of Dexmedetomidine/Ketamine for potential Airway Catastrophe
Evaluation of Children with Obstructive Sleep Apnea

**Obstructive apnea**

**Obstructive hypopnea**

<table>
<thead>
<tr>
<th>Severity of OSA</th>
<th>Adult AHI</th>
<th>Pediatric AHI</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>0–5</td>
<td>0</td>
</tr>
<tr>
<td>Mild OSA</td>
<td>6–20</td>
<td>1–5</td>
</tr>
<tr>
<td>Moderate OSA</td>
<td>21–40</td>
<td>6–10</td>
</tr>
<tr>
<td>Severe OSA</td>
<td>&gt;40</td>
<td>&gt;10</td>
</tr>
</tbody>
</table>
Identification of Sites of Upper Airway Obstruction

• Flexible endoscopy
  - In the office setting or operating room
• Lateral neck x-ray
• Fluoroscopy of airway
• Cine CT
• Cine MRI
New Diagnostic Modality

- Anatomy
- Upper Airway Function
- Collapsibility
- Compliance
Computational Study on Obstructive Sleep Apnea Syndrome Using Patient–Specific Models


(a)

(b)

Outlet

Outlet

\[
A_{\text{first}}
\]

\[
A_{\text{min}}
\]

TABLE I

<table>
<thead>
<tr>
<th></th>
<th>(A_{\text{first}}) (cm(^2))</th>
<th>(A_{\text{min}}) (cm(^2))</th>
<th>Percentage of Stenosis</th>
<th>Resistance (Pa s L(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre–operation</td>
<td>3.3</td>
<td>0.6</td>
<td>80.5%</td>
<td>40.2</td>
</tr>
<tr>
<td>Post–operation</td>
<td>3.3</td>
<td>1.7</td>
<td>49.0%</td>
<td>24.3</td>
</tr>
</tbody>
</table>
MRI Sleep Study

Airway evaluation:

**Static Images**

**Dynamic Images**

128 consecutive images over 2 minutes

MRI Sleep Study
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
Hypopharyngeal collapse
Glossoptosis
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
Drug Induced Sleep Endoscopy (DISE)
Drug Induced Sleep Endoscopy (DISE)
Drug Induced Sleep Endoscopy (DISE)
Case:

- 3 year old 16.4 kg
- History of OSA, S/P T&A and 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)
Why Do We Struggle?
Oral Airway Intervention
Nasal Airway Intervention
Fleck et al. Effect of Positive Airway Pressure on the Upper Airway Documented with Magnetic Resonance Imaging” JAMA Otolaryngology, 2013 Jun 1;139(6):636-8
Anesthesia and Dynamic Upper Airway Evaluation

- Dexmedetomidine
- Propofol
- Dexmedetomidine and Ketamine
## Dexmedetomidine VS Propofol for MRI Sleep Studies

<table>
<thead>
<tr>
<th>Artificial Airway, N (%)</th>
<th>All Subjects</th>
<th>Subjects with Polysomnography Study Available</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dexmedetomidine</td>
<td>Propofol</td>
</tr>
<tr>
<td></td>
<td>(N=52)</td>
<td>(N=30)</td>
</tr>
<tr>
<td>None</td>
<td>47 (90)</td>
<td>21 (70)</td>
</tr>
<tr>
<td>Intermittent</td>
<td>5 (10)</td>
<td>9 (30)</td>
</tr>
<tr>
<td>Chin Lift or Shoulder Roll, N (%)</td>
<td>1 (2)</td>
<td>3 (10)</td>
</tr>
<tr>
<td>Any Airway Intervention, N (%)</td>
<td>6 (12)</td>
<td>12 (40)</td>
</tr>
<tr>
<td>Interpretable MRI Scan, N (%)</td>
<td>51 (98)</td>
<td>30 (100)</td>
</tr>
<tr>
<td>With Native Airway, N (%)</td>
<td>46 (88)</td>
<td>21 (70)</td>
</tr>
<tr>
<td>With Artificial Airway, N (%)</td>
<td>5 (10)</td>
<td>9 (30)</td>
</tr>
</tbody>
</table>

### Requirement for Artificial Airway by Severity of OSA as Documented by Polysomnography

<table>
<thead>
<tr>
<th>OSA Severity</th>
<th></th>
<th>Dexmedetomidine</th>
<th>Propofol</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>N = 16</td>
<td>N = 8</td>
<td></td>
</tr>
<tr>
<td>Mild</td>
<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></td>
<td>Respiratory Disturbance Index (events/hour)</td>
<td>3.6 ± 1.9</td>
<td>4.4 ± 1.7</td>
<td>0.30†</td>
</tr>
<tr>
<td></td>
<td>Needed Artificial Airway, N (%)</td>
<td>2 (13)</td>
<td>1(13)</td>
<td>1‡</td>
</tr>
<tr>
<td>Moderate</td>
<td>N = 11</td>
<td>N = 9</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Obstructive Index (events/hour)</td>
<td>10.2 ± 5.8</td>
<td>8.8 ± 3.8</td>
<td>0.54‡</td>
</tr>
<tr>
<td></td>
<td>Respiratory Disturbance Index (events/hour)</td>
<td>11.0 ± 5.8</td>
<td>10.9 ± 4.3</td>
<td>0.96†</td>
</tr>
<tr>
<td></td>
<td>Needed Artificial Airway, N (%)</td>
<td>2 (18)</td>
<td>3 (33)</td>
<td>0.62‡</td>
</tr>
<tr>
<td>Severe</td>
<td>N = 14</td>
<td>N = 9</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Obstructive Index (events/hour)</td>
<td>21.8 ± 11.3</td>
<td>23.6 ± 13.5</td>
<td>0.74‡</td>
</tr>
<tr>
<td></td>
<td>Respiratory Disturbance Index (events/hour)</td>
<td>23.8 ± 11.2</td>
<td>24.9 ± 13.1</td>
<td>0.83‡</td>
</tr>
<tr>
<td></td>
<td>Needed Artificial Airway, N (%)</td>
<td>1 (7)</td>
<td>5 (56)</td>
<td>0.02‡</td>
</tr>
</tbody>
</table>

Are there qualitative differences in the hypnotic response produced by DEX

- Provides sedation without significant respiratory depression\(^1\text{-}^4\)
- Sedative properties that parallel natural sleep \(^2\text{-}^4\)

Hypnotic Effect of DEX

NREM Sleep

cortex
subcortical areas

rostral hypothalamus

basal forebrain

pons

histaminergic
tuberomammillary
nucleus

galanin- and GABAergic
ventrolateral preoptic
nucleus

noradrenergic
locus coeruleus

TMN

(-) gal
GABA (-)

VLPO

LC
Pharyngeal Dilator Muscle Activation
Effect of increasing depth of dexmedetomidine anesthesia on upper airway morphology in children

MOHAMED MAHMOUD MD, RUPA RADHAKRISHMAN MBBS, JOEL GUNTER MD, SENTHILKUMAR SADHASIVAM MD, MPH, ANDREW SCHAPIRO BS†, JOHN McCAULIFFE MD, MBA, DEAN KURTH MD, YU WANG MS†, TODD G. NICK PhD† AND LANE F. DONNELLY MD†

Low DEX 1 mcg/kg/h

Research Images

High DEX 3 mcg/kg/h

Diagnostic Brain

Research Images
• Static Measurements
  Axial SSFSE
  Retroglossal Area
  AP diameter
  Trans diameter
Dynamic Measurements
FGE Cine
NP Area
NP diameter
RG Area
RG diameter
Min/Max
Critical Closing Pressure during Dex-induced Sleep
Effect Of Dexmedetomidine On Upper Airway Collapsibility In Children With Down’s Syndrome

K. McConnell¹, R. S. Amin², S. Shott², R. Fleck², M. Mahmoud², S. Salisbury², E. Gutmark³, S. Khosla³, S. Serai², L. Donnelly⁴,
¹Cincinnati Children’s Hospital Medical Center, Cincinnati, OH, ²Cincinnati Children’s Hospital Medical Center, Cincinnati, ³University of
Cincinnati, Cincinnati, ⁴Nemours Children’s Hospital, Orlando, FL

Results

Subject 1: Male, 5 y/o, OI = 9.6

Subject 2: Male, 21 y/o, OI = 35.2

Subject 3: Male, 8 y/o, OI = 7.0

Subject 4: Female, 10 y/o, OI = 5.3

Subject 5: Male, 4 y/o, OI = 5.7
• Mean **sleep** \( P_{crit} = -4.94 \text{ cmH2O} \)
• Mean **dexmedetomidine** \( P_{crit} = -4.78 \text{ cmH2O} \)
  \((p = 0.375)\)
Does propofol affect sleep architecture?

PSG evaluation in OSA patients

Rabelo FA, Otolaryngol 2010

<table>
<thead>
<tr>
<th>Examination</th>
<th>N1</th>
<th>N2</th>
<th>N3</th>
<th>REM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diurnal</td>
<td>24.1</td>
<td>47.7</td>
<td>15.3</td>
<td>12.7</td>
</tr>
<tr>
<td>Propofol</td>
<td>3.3</td>
<td>43.8</td>
<td>50.4</td>
<td>0.0</td>
</tr>
<tr>
<td><em>P</em></td>
<td>&lt;0.0001</td>
<td>ns</td>
<td>0.0017</td>
<td>0.0004</td>
</tr>
</tbody>
</table>

Propofol significantly changed sleep architecture

<table>
<thead>
<tr>
<th>Examination</th>
<th>No. of apneas</th>
<th>No. of hypopneas</th>
<th>AHI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diurnal</td>
<td>10.1</td>
<td>25.6</td>
<td>13.7</td>
</tr>
<tr>
<td>Propofol</td>
<td>14.2</td>
<td>10.5</td>
<td>14.6</td>
</tr>
<tr>
<td><em>P</em></td>
<td></td>
<td></td>
<td>ns</td>
</tr>
</tbody>
</table>
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
Collapsibility of the Upper Airway at Different Concentrations of Propofol Anesthesia

Peter R. Eastwood, Ph.D., * Peter R. Platt, M.D., † Kelly Shepherd, B.Sc., ‡ Kathy Maddison, B.Sc., ‡ David R. Hillman, M.D. §
Safety and Efficacy of Drug-Induced Sleep Endoscopy Using a Probability Ramp Propofol Infusion System in Patients with Severe Obstructive Sleep Apnea

Joshua H. Atkins, MD, PhD,* Jeff E. Mandel, MD, MS,* and Giulia Rosanova, BA†

Table 1. Demographics of Analyzed Patients

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y) (mean ± SD)</td>
<td>48.8 ± 9.0 y</td>
</tr>
<tr>
<td>Gender</td>
<td>F: 14; M: 83</td>
</tr>
<tr>
<td>Height (mean ± SD)</td>
<td>1.77 ± 0.91 m</td>
</tr>
<tr>
<td>Weight (mean ± SD)</td>
<td>102.6 ± 19.5 kg</td>
</tr>
<tr>
<td>BMI (median [IQR])</td>
<td>32.1 (6.8) kg/m²</td>
</tr>
<tr>
<td>AHI (median [IQR])</td>
<td>48 (32)</td>
</tr>
<tr>
<td>Sleep study Sao₂ nadir (Median [IQR])</td>
<td>81.0 (11.2)%</td>
</tr>
</tbody>
</table>
Safety and Efficacy of Drug-Induced Sleep Endoscopy Using a Probability Ramp Propofol Infusion System in Patients with Severe Obstructive Sleep Apnea

Joshua H. Atkins, MD, PhD,* Jeff E. Mandel, MD, MS,* and Giulia Rosanova, BA†
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
Dexmedetomidine and Ketamine

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

Ketamine prevents:
- Bradycardia
- Hypotension
Airway Catastrophe
Airway Catastrophe
Airway Catastrophe
Congenital Lobar Emphysema
Dexmedetomidine for Thyroplasty
Conclusion

• Understanding the goal of the procedure is essential to obtain a high-quality evaluation

• Dexmedetomidine is the sedative agent of choice for dynamic upper airway evaluation
Thank You