CLINICAL IMAGING OF THE PEDIATRIC UPPER AIRWAY

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Disclosure Slide

• No disclosures
Presentation

• Why do we image children with obstructive sleep apnea?
• What are some of the findings on MRI?
• How do you start a program?
• Understanding surgical options/outcomes?
Obstructive Sleep Apnea (OSA)

• Common – 3% of children
• Problematic – associated with
  – Daytime sleepiness
  – Hyperactivity
  – Attention Deficit Disorder
  – Learning problems
  – Failure to thrive
• Straight forward treatment
Obstructive Sleep Apnea

• Straight forward
  – Healthy, normal children
  – Diagnosis by physical examination and lateral radiograph
  – Enlarged adenoids and palatine tonsils

• More Severe
  – Down syndrome
  – Craniofacial anomalies
  – Obesity
  – Asthma
Persistent OSA in children

- Mitchell 2007: 10-20% incidence of persistent sleep apnea in a group of 79 typical children after T&A
- Tauman et al. 2006: complete normalization of all components evaluated in a sleep study in only 25% of their test population of ‘typical’ children
- Bhattacharjee et al 2010: 6 center study of 578 ‘typical’ children undergoing T&A 73% had mild or greater OSA post surgery; 22% moderate OSA. Risk factors were obesity, age greater than 7 yo, severity of OI pre-op, and asthma in non-obese
Obstructive Sleep Apnea

• Subgroup of more severe OSA
  – Failed prior surgery (T&A)
  – Down syndrome
  – Craniofacial anomalies
  – Obesity
  – Polycystic ovarian syndrome (PCOS)
  – Turner syndrome
Down Syndrome

• Higher probability of developing OSA
• Even if asymptomatic
• Higher risk due to:
  – Midface hypoplasia
  – Narrow nasopharynx
  – Large tongue
  – Muscular hypotonia
  – Increased URI’s
  – Small larynx and trachea
Causes for Persistent OSA

• Enlarged lingual tonsils
Lingual Tonsillectomy for Treatment of Pediatric Obstructive Sleep Apnea
A Meta-analysis

- 4 studies, 73 patients
- AHI < 1 events/hour success 17%
- AHI < 5 events/hour, success 51%
- Mean reduction was 8.9 events/hour
Causes for Persistent OSA

- Enlarged lingual tonsils
- Enlarged recurrent adenoids
Causes for Persistent OSA

- Image motion
  - Sagittal Cine
  - Axial Cine
- Definite advantage
- Hypopharyngeal Collapse
Causes for Persistent OSA

Glossoptosis

• Posterior displacement of tongue into the pharynx
  – Passive falling posterior
  – Mass effect due to macroglossia or relative macroglossia
  – Dynamic form of collapse with piston like movement
Causes for Persistent OSA

• Laryngomalacia
  – Newly recognized on MR
  – Confirmed by DISE
  – Usually not present this late in life!
Causes for Persistent OSA

- Epic Laryngomalacia

Airway

Arytenoids

“Epic Laryngomalacia”
How to start a program?

• Is there a need?
  – Usually driven by an otolaryngologist
  – Less driven by pulmonology

• Need an anesthesiologist

• Radiologist and technologist

• MRI scanner – No special bells or whistles
Sedation and Preparation of Patient

- Patient is induced with sevoflurane in the induction room
- IV is started
- Sedation initiated with a bolus dose of dexmedetomidine (1 mcg/kg)
- Continuous infusion of dexmedetomidine (1 mcg/kg/h)
- Transferred to the MRI head is positioned at Frankfort angle of ~90 degrees – angle created by a line parallel to the Z-axis and inferior orbit to external auditory canal
Maintenance of Airway

These patients are all critical airway patients for anesthesia.

Often an oral airway is placed during induction:
  - Should be removed before imaging.
  - Head strap should be positioned so that a mask can be used for CPAP if required to maintain airway.

Order of preference for maintaining airway:
  - Mask with CPAP
  - Nasal Trumpet
  - Never desirable – Oral airway, LMA (Sometimes information can be gained from anatomic imaging but airway needs to be removed for Cine images.)
Possible alternative: 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
**Requirement for Artificial Airway by Severity of OSA as Documented by Polysomnography**

<table>
<thead>
<tr>
<th>OSA Severity</th>
<th>Dexmedetomidine</th>
<th>Propofol</th>
<th>P-value</th>
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</thead>
<tbody>
<tr>
<td>Mild</td>
<td></td>
<td></td>
<td></td>
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<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>
<tr>
<td>Needed Artificial Airway, N (%)</td>
<td>2 (13)</td>
<td>1 (13)</td>
<td>1†</td>
</tr>
<tr>
<td>Moderate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<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>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>Needed Artificial Airway, N (%)</td>
<td>2 (18)</td>
<td>3 (33)</td>
<td>0.62‡</td>
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<tr>
<td>Severe</td>
<td></td>
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<tr>
<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>Respiratory Disturbance Index (events/hour)</td>
<td>23.8 ± 11.2</td>
<td>24.9 ± 13.1</td>
<td>0.83†</td>
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<td>Needed Artificial Airway, N (%)</td>
<td>1 (7)</td>
<td>5 (56)</td>
<td>0.02‡</td>
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</table>
Clinical Protocol

- Head and neck vascular or cervical spine coil
- Localizers
- Sag PD CUBE no fat sat – VISTA on Philips, SPACE on Siemens; Respiratory Triggered
- Sag Cine Airway - Midline
- Axial Cine Airway – Retroglossal and nasopharynx
- Axial T2 Fat Sat Multivane
- Sag STIR or T2 Fat Sat Multivane
- Stack of Axial Cine of airway from choana through the glottis
Isotropic Resolution of ~0.5mm allows reformats in any plane
Retroglossal Airway

Nasopharyngeal Airway

Retroglossal Airway
Sagittal Midline Cine

Retroglossal Airway

Nasopharyngeal Airway
SSFP or GRE Cine Airway Image 128 X 128 pixels, FOV 240 mm, Slice Thickness 5mm, TR 3.239, TE 1.128, Flip angle 65

Best Temporal Resolution ~200 ms

15 images per respiratory cycle

Minimizes blurring
No under sampling
Recap of Clinical Protocol

- Head and neck vascular or cervical spine coil
- Localizers
- Sag PD CUBE no fat sat – VISTA on Philips, Respiratory Triggered
- Sag Cine Airway - Midline
- Axial Cine Airway – Retroglossal and nasopharynx
- Axial T2 Fat Sat Multivane
- Sag T2 Fat Sat Multivane or STIR
Practical Issues

- Position as close to natural sleeping position as possible
- May need to augment airway
  - Image every sequence
  - Remove repeat axial and sag cine
- Anesthesia was uncomfortable at first
  - Patients obstruct and desaturate during sleep
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%
Advantage of Imaging

- Image motion
  - Sagittal Cine
  - Axial Cine
  - Effect of CPAP

12 cm CPAP  0 cm CPAP
Advantage of Imaging

- Image motion
  - Sagittal Cine
  - Axial Cine
  - Effect of CPAP

12 cm CPAP

0 cm CPAP
Advantage of Imaging
Other Findings

• Thornwaldt cyst
Other Findings

- Vallecular cyst
Other Findings

Atlantoaxial subluxation impinging on the spinal cord
UNUSUAL CASES
Surgical Option

• Depends on level(s) of residual obstruction
  – Base of tongue collapse
  – Oropharyngeal collapse
  – Nasopharyngeal collapse
  – Hypopharyngeal collapse
Surgical Options

Lingual Tonsillectomy

Redo Adenoidectomy
Surgical Options

• Down Syndrome
  – Relative macroglossia
  – Glossoptosis
Surgical Options
Wedge Resection Base of Tongue
Surgical Options

• Genioglossus Advancement
  – Suture is tied down so that indentation and retraction of posterior tongue can be palpated transorally
Surgical Options

• 31 patients, 19 with Down syndrome
• Polysomnography (PSG) 2-24 months after surgery, average = 5.6 months
• PSG success if AHI<5 events per hour, Oxygen saturation >90%, sleep duration with end-tidal CO$_2$ exceeding 50 mmHg<10%
• 58% success in DS patients
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| Kathleen VanDeGrift, RC    |
| Jenny Jeffries, RRN        |

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