Update in pediatric Obstructive sleep apnea

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Ramathibody hospital
Obstructive sleep apnea

- **Definition:**

  Absence of oronasal airflow in the presence of continued respiratory effort lasting longer than two respiratory cycle times
## Sleep disorder breathing

<table>
<thead>
<tr>
<th>Primary Snoring (PS)</th>
<th>Upper airway resistance syndrome (UARS)</th>
<th>Obstructive hypoventilation or obstructive hypopnea (OH)</th>
<th>Obstructive sleep apnea (OSA)</th>
</tr>
</thead>
</table>

Prevalence

- **Young et al 2002 : Europe and America**
  - Age $\leq$ 6 yr
    - Habitual snoring 10-14 %
    - OSA 2-3 %

- **Ng et al 2005 : Hong Kong**
  - Age 6-12 yr
    - Habitual snoring 11 %
    - Witness sleep apnea 1.5 %

Prevalence

• **Wanaporn et al 2001: Songkla**
  
  School-age children
  
  Habitual snoring  8.5 %
  
  OSA  0.69 %
### Table 1
Childhood vs adult obstructive sleep apnea syndrome

<table>
<thead>
<tr>
<th></th>
<th>Children</th>
<th>Adult</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Presentation</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>Peak 2–6 y</td>
<td>Increases in elderly</td>
</tr>
<tr>
<td>Gender</td>
<td>Male = female</td>
<td>Males 2× &gt; female</td>
</tr>
<tr>
<td>Associated obesity</td>
<td>Minority of patients</td>
<td>Majority of patients</td>
</tr>
<tr>
<td>Underweight/failure to thrive</td>
<td>Frequent finding</td>
<td>Not seen</td>
</tr>
<tr>
<td>Enlarged tonsils and adenoids</td>
<td>Frequent finding</td>
<td>Not seen</td>
</tr>
<tr>
<td>Excessive daytime sleepiness</td>
<td>Infrequent</td>
<td>Common, often severe</td>
</tr>
<tr>
<td><strong>Sleep</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Obstruction</td>
<td>Obstructive apnea or obstructive hypoventilation</td>
<td>Obstructive apnea</td>
</tr>
<tr>
<td>Sleep architecture</td>
<td>Normal</td>
<td>Decreased delta and rapid eye movement</td>
</tr>
<tr>
<td>Arousals</td>
<td>May not be seen</td>
<td>At end of each apnea</td>
</tr>
<tr>
<td><strong>Treatment</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surgical</td>
<td>Definitive therapy in most patients</td>
<td>In minority of cases</td>
</tr>
<tr>
<td>Medical (positive airway pressure)</td>
<td>In selected patients</td>
<td>Most common therapy</td>
</tr>
</tbody>
</table>
Table 2
Medical conditions associated with obstructive sleep apnea syndrome (OSAS)

<table>
<thead>
<tr>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Achondroplasia</td>
</tr>
<tr>
<td>Apert’s syndrome</td>
</tr>
<tr>
<td>Beckwith-Wiedemann syndrome</td>
</tr>
<tr>
<td>Cerebral palsy</td>
</tr>
<tr>
<td>Choanal stenosis</td>
</tr>
<tr>
<td>Cleft palate patients following repair</td>
</tr>
<tr>
<td>Crouzon syndrome</td>
</tr>
<tr>
<td>Cystic hygroma</td>
</tr>
<tr>
<td>Down syndrome</td>
</tr>
<tr>
<td>Hallermann-Streiff syndrome</td>
</tr>
<tr>
<td>Hypothyroidism</td>
</tr>
<tr>
<td>Klippel-Feil syndrome</td>
</tr>
<tr>
<td>Mucopolysaccharidosis</td>
</tr>
<tr>
<td>Obesity</td>
</tr>
<tr>
<td>Osteopetrosis</td>
</tr>
<tr>
<td>Papillomatosis (oropharyngeal)</td>
</tr>
<tr>
<td>Pierre Robin syndrome</td>
</tr>
<tr>
<td>Pfeiffer’s syndrome</td>
</tr>
<tr>
<td>Pharyngeal flap surgery</td>
</tr>
<tr>
<td>Prader Willi syndrome</td>
</tr>
<tr>
<td>Sickle cell disease</td>
</tr>
<tr>
<td>Treacher-Collins syndrome</td>
</tr>
</tbody>
</table>
## Patency of upper airway during sleep

### Neuromuscular factors
- Pharyngeal dilating muscle
  - Tonic activity
  - Phasic contraction in response to negative upper airway pressure

### Structural factors
- Upper airway structure
- Enlarge tonsils and adenoid
- Nasal mucosa swelling
- Pharyngeal fat pad
Inflammation in SDB

- C-reactive protein
- Adhesion molecules
- Cysteinylleukotriene in urine
- Cysteinylleukotriene in exhaled breath
- Interleukin-6 (pro-inflammatory cytokines) : increase
- Interleukin-10 (anti-inflammatory cytokines) : decrease

- Pathogenesis of SDB
- End-organ morbidity
- Marker for diagnosis
Plasma C-reactive protein levels among children with SDB
Urine cysteinyl-LT in children with SDB

<table>
<thead>
<tr>
<th>Severity</th>
<th>Log-transformed urine cyst-LT</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mod to severe</td>
<td></td>
<td>2.39</td>
<td>0.51</td>
</tr>
<tr>
<td>Mild</td>
<td></td>
<td>2.06</td>
<td>0.26</td>
</tr>
<tr>
<td>Primary snoring</td>
<td></td>
<td>2.11</td>
<td>0.25</td>
</tr>
<tr>
<td>Control</td>
<td></td>
<td>1.86</td>
<td>0.28</td>
</tr>
<tr>
<td>P value</td>
<td></td>
<td>&lt;0.05</td>
<td></td>
</tr>
</tbody>
</table>

KaditisAG. Chest 2009: Epubahead of print
Leukotriene Pathways and *In Vitro* Adenotonsillar Cell Proliferation in Children With Obstructive Sleep Apnea*

Ehab Dayyat, MD; et.al

**Results:**

- LTD4 elicited dose-dependent increases in adenotonsillar cell proliferation ($p < 0.001$; n 12).

- All three antagonists reduced TNF-α, IL-6, and IL-12 concentrations, with selective changes in IL-8 and no effects on IL-10 levels.
Figure 3. Representative overlaid microscope images of CD4 and cysLT1 cellular expression from intact tonsillar tissues in children with OSA. Expression of CD4 (green) and cysLT1 receptor (red) immunoreactivity is abundant, and colocalization occurs frequently (top left, A, 20 magnification; bottom left, B, and top right, C, 40 magnification; bottom right, D, 100 magnification). Similar findings emerged in the tonsils of five OSA subjects.
Evidence for activation of nuclear factor kappaB in obstructive sleep apnea

Motoo Yamauchi & Shinji Tamaki & Koichi Tomoda ;et.al

- OSA is risk factor for atherosclerosis, and atherosclerosis evolves from activation of inflammatory cascade.

- activation of NF-kappaB, key transcription factor in inflammatory cascade, occurs in OSA.

The role of the nose in the pathogenesis of obstructive sleep apnoea and snoring

M. Kohler*, K.E. Bloch#," and J.R. Stradling*

- chronic nasal obstruction play a minor role in pathogenesis of OSA, and some relevance in origin of snoring.
- The impact of treating nasal obstruction in patients with snoring and obstructive sleep apnoea on long-term outcome remains to be defined through randomised controlled trials of medical and surgical therapies.
<table>
<thead>
<tr>
<th>First author [Ref.]</th>
<th>Number and characteristics of patients</th>
<th>Study design, intervention</th>
<th>Outcomes</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bahammam [62]</td>
<td>18, snorers with UARS, mean AHI 8.9, no information on nasal complaints</td>
<td>Crossover, Breathe Right® versus placebo strips</td>
<td>Improved desaturation time and sleep architecture, no difference in AHI, arousal index, MSLT</td>
<td>Nasal dilation resulted in an increase of nasal cross-sectional area \ No data on snoring</td>
</tr>
<tr>
<td>Pevernage [63]</td>
<td>12, snorers, mean AHI 6, chronic rhinitis and nasal obstruction</td>
<td>Crossover, Breathe Right® versus placebo strips</td>
<td>Decrease in snoring events, no difference in AHI, arousal index and sleep architecture</td>
<td>Nasal dilation resulted in a nearly significant reduction of NR</td>
</tr>
<tr>
<td>Djupesland [64]</td>
<td>18, heavy snorers, median AHI 9.3, nocturnal nasal obstruction</td>
<td>Crossover, Breathe Right® versus placebo strips</td>
<td>No difference in ODI, snoring time and sleep architecture</td>
<td>Nasal dilation resulted in an increase in total nasal cross-sectional area and volume</td>
</tr>
<tr>
<td>Schönhofer [65]</td>
<td>38, OSA patients undergoing CPAP titration, AI 17.1, no information on nasal complaints</td>
<td>Crossover, Nozovent® versus no intervention</td>
<td>Increase in AHI with active dilator \ Decrease of CPAP pressure, no difference in AI, \ $S_{p,o_2}$</td>
<td>Nasal dilation was not controlled by objective or subjective measurement</td>
</tr>
<tr>
<td>Höjer [66]</td>
<td>10, mainly mild OSA, mean AI 18, no nasal complaints</td>
<td>Crossover, Nozovent® versus no intervention</td>
<td>Decrease in snoring events, AI, and minimal $S_{p,o_2}$</td>
<td>Nasal dilation resulted in an increase in nasal airflow</td>
</tr>
<tr>
<td>First author</td>
<td>Number and characteristics of patients</td>
<td>Study design, intervention</td>
<td>Outcomes</td>
<td>Comments</td>
</tr>
<tr>
<td>--------------</td>
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</tr>
<tr>
<td><strong>KELLY [67]</strong></td>
<td>23, 10 snorers and 13 OSA patients, median AHI of OSA patients 26.5, chronic allergic rhinitis</td>
<td>Crossover, double-blind, intranasal fluticasone versus placebo (saline)</td>
<td>AHI and subjective NR decreased</td>
<td>Fluticasone decreased NR</td>
</tr>
<tr>
<td><strong>MCLEAN [68]</strong></td>
<td>10, moderate-severe OSA, chronic nasal obstruction</td>
<td>Crossover, single-blind, intranasal oxymetazoline and Breathe Right® versus placebo strips and sodium chloride</td>
<td>AHI and sleep architecture improved, and mouth breathing decreased</td>
<td>Oxymetazoline and Breathe Right® reduced NR</td>
</tr>
<tr>
<td><strong>KERR [69]</strong></td>
<td>10, moderate-to severe OSA, six out of 10 with chronic nasal obstruction</td>
<td>Crossover, single-blind, intranasal oxymetazalone and vestibular stents versus placebo (saline)</td>
<td>Arousal index (and sleep architecture in patients with nasal obstruction) improved</td>
<td>No data on snoring</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>No change in subjective sleepiness</td>
<td>No data on snoring</td>
</tr>
</tbody>
</table>
Clinical findings
Pertinent clinical findings in pediatric OSA

- **During sleep**
  - Habitual snoring
  - Difficulty breathing during sleep with snoring episodes
  - Restless sleep and frequent awakenings
  - Excessive sweating
  - Night terrors
  - Enuresis
  - Breathing pauses reported by parents

*Kendig’s Disorders of the Respiratory tract in Children; 2006*
Pertinent clinical findings in pediatric OSA

- **During daytime**
  - Mouth breathing and limited nasal airflow
  - Chronic rhinorrhea
  - Adenoid facies
  - Recurrent ear infections
  - Difficulty swallowing
  - Pectus excavatum
  - Retrognathia
  - Enlarged neck circumference
  - Truncal obesity
  - Frequent visits to primary care physician for respiratory-related symptoms

Kendig’s Disorders of the Respiratory tract in Children; 2006
Pertinent clinical findings in pediatric OSA

**Sequelae**

- Neurobehavioral deficits
- ADHD-like behaviors
- Depression and low self-esteem
- Excessive daytime sleepiness
- Systemic hypertension
- Left ventricular hypertrophy
- Pulmonary hypertension and cor pulmonale
- Failure to thrive
- Reduced quality of life

Kendig’s Disorders of the Respiratory tract in Children; 2006
Sequelae of OSA in children

- **Cardiopulmonary**
  - Right/Left ventricular hypertrophy
  - Pulmonary hypertension, Cor pulmonale
  - Systemic hypertension

- **Neurodevelopment**
  - Hyperactivity
  - Hypersomnolence
  - Poor school performance
  - Mood and behavior problem

<table>
<thead>
<tr>
<th>Table 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk factors for respiratory compromise following adenotonsillectomy for obstructive sleep apnea syndrome (OSAS)</td>
</tr>
<tr>
<td>Age younger than 3 years</td>
</tr>
<tr>
<td>Severe OSAS on polysomnography</td>
</tr>
<tr>
<td>Cardiac complications of OSAS</td>
</tr>
<tr>
<td>Morbid obesity</td>
</tr>
<tr>
<td>Failure to thrive</td>
</tr>
<tr>
<td>History of premature birth</td>
</tr>
<tr>
<td>Congenital heart disease</td>
</tr>
<tr>
<td>Recent respiratory infection</td>
</tr>
<tr>
<td>Neuromuscular disorders</td>
</tr>
<tr>
<td>Craniofacial anomalies</td>
</tr>
<tr>
<td>Chromosomal disorders</td>
</tr>
</tbody>
</table>
Approach to child with suspected OSA

• **Sleep history**
  - Usual bedtime
  - Behavior at bedtime
  - During sleep and upon awakening
  - Duration of sleep
  - Naps
  - Sleep positions
  - Restless sleep
  - Enuresis

Sleep and breathing in children; volume 147
Approach to child with suspected OSA

- **Snoring**
  - Frequency of nocturnal snoring
  - Onset
  - Pitch
  - Quality
  - Loudness
  - Presence of periods of silence
  - Assessment of difficulty with breathing
  - Parental concerns about their child’s breathing
Approach to child with suspected OSA

- **Findings awake**
  - History of recurrent adenotonsillar disease or chronic rhinitis, altered growth and development patterns
  - Functional status: developmental status, school performance, personality changes, behavior upon awakening, morning headaches or irritability
  - Associated cardiopulmonary or genetic syndromes
Approach to child with suspected OSA

- **Physical examination**
  - Vital signs including height, weight, and blood pressure
  - Complete ear/nose/throat exam with emphasis on adenotonsillar hypertrophy
  - Craniofacial examination
  - Cardiac exam for evidence of cor pulmonale
  - Digital clubbing
Laboratory evaluation
Laboratory evaluation

Test to determine diagnosis

- **Screening studies studies**
  - Clinical scoring systems
  - Audio-and/or videotaping
  - Cinefluoroscopy of upper airway
  - Nasal endoscopy during natural sleep
  - Nocturnal oximetry
  - Nap studies
Screening OSA by home videotapes recording

- Thirty minutes of home video-recordings
- Highly correlation between PSG results and video test results
- Overall sensitivity 94%, specificity 68%

Sivan Y. EurRespirJ. 1996;9:2127-2131
Overnight oximetry monitoring

Oxygen sat < 90% At least 3 times / night

Positive predictive value 97%

Negative predictive value 47%

BrouiletteRT. Pediatrics 2000;105:405-412
Laboratory evaluation

Diagnostic studies

- **Polysomnography**: Gold Standard
  - EEG, EOG, EMG to stage sleep and detect arousal
  - EKG
  - Respiratory monitoring
    - Abdominal and chest wall movements
    - Airflow
    - Ventilation
    - Oxygenation
    - Respiratory effort

Measures of Sleep Apnea Frequency

- **Apnea Index**
  - (Obstructive) apneas per hour of sleep
- **Apnea / Hypopnea Index (AHI)**
  - apneas + hypopneas per hour of sleep
- **RERA** = respiratory effort-related arousal
Polysomnography

- Normal Polysomnographic Values
  - Apnea hypopnea index 0.1 ± 0.5
  - No obstructive apnea > 10 s
  - Central apnea
  - $O_2$ Sat was 96 ± 2 %
  - Apnea index < 1 using apneas of any duration

Marcus et al 1992
Polysomnography

Obstructive Sleep Apnea

- Apnea hypopnea index > 1/hr
- Arousal index > 10/hr
- Saturation < 90%
- Hypoventilation
  - $\text{ETCO}_2 > 50 \text{ mmHg (25\% of TST)}$
Laboratory evaluation

- Test to identify predisposing conditions
  - Anteroposterior and lateral neck radiographs
  - Upper airway fluoroscopy
  - Endoscopy
  - Brainstem MRI or CT
Laboratory evaluation

- **Test to determine severity**
  - Hemoglobin and hematocrit
  - Serum bicarbonate
  - Echocardiogram
  - Neuropsychological evaluation
  - Polysomnography
OSA Update Diagnostic

- RDI > 1, AHI > 1, AI > 1
- Cortisal, Subcortisal (BP↓), Pulse transit time (normal 200-300 m)
- Urine protein selgolin, perlican
- Serum Apolipoprotein E
- Clinical score
Pulse transit time for scoring subcortical arousal in infants with obstructive sleep apnea

Alessandra Rizzoli & Michael S. Urschitz; et.al

- **Results:**
  - Uninterpretable PTT signal appeared in 394 (65%) apneas and were due to a disturbed pulse waveform in 63%.

- **Conclusion:**
  - The feasibility of PTT in scoring apnea-related subcortical arousals in infants may be questionable.
  - However, scoring spontaneous PTT arousals may be an approach for assessing sleep disruption in infants with obstructive sleep apnea.

Pulse transit time for scoring subcortical arousal in infants with obstructive sleep apnea

- PTT was calculated using same specific sleep analysis software (Hypnolab, SWS Soft).
- For the calculation of PTT by software, the sampling frequency for both electrocardiogram and pulse waveform had to be at least 100 Hz.
- PTT was calculated as the time elapsing between occurrence of the electrocardiographic R-wave and point on the pulse waveform that is 50% of the maximum value.
Fig. 1 Examples of obstructive apneas followed by uninterpretable PTT signal due to a disturbed pulse waveform (continuous lines). Abbreviations: PTT, pulse transit time.
Fig. 2 Examples of obstructive apneas followed by PTT arousals (continuous lines). Abbreviations: PTT, pulse transit time
Serum Cardiovascular Risk Factors in Obstructive Sleep Apnea*  

*Murat Can, MD; Sedefden Acikgoz, MD; et.al

**Background:** Obstructive sleep apnea (OSA) patients have increased cardiovascular morbidity and mortality. The cardiovascular markers associated with OSA are currently not defined.

**Objectives:** The aims of this study were to determine whether OSA is associated with serum cardiac risk markers and to investigate the relationship between them.

**Methods:** Sixty-two male patients were classified into two groups with respect to apnea-hypopnea index (AHI): group 1, sleep apnea (n = 30), with AHI > 5; and group 2 (n = 32), with AHI < 5. We compared cardiovascular risk factors in both groups with control subjects (n = 30) without OSA (AHI < 1). Serum cholesterol, triglyceride, high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), apolipoprotein A-I, apolipoprotein B, lipoprotein (a), C-reactive protein (CRP), and homocysteine were measured. Statistical significance was assessed with analysis of variance at \( p < 0.05 \). In correlation analysis, Pearson correlation was used.

**Results:** There was no significant difference between group 1 and group 2 in total cholesterol, LDL-C, HDL-C, triglyceride, apolipoprotein A-I, apolipoprotein B, and lipoprotein (a). All of the M-mode echocardiographic parameters were in the normal reference range. Serum homocysteine and CRP levels were significantly increased in group 1 compared to group 2 (\( p < 0.05 \)). Serum CRP values were increased in both group 1 and group 2 when compared with control subjects (\( p < 0.05 \)). Serum homocysteine values were higher in group 1 than in control subjects (\( p < 0.05 \)).

**Conclusions:** Our results show that OSA syndrome is associated not only with slight hyperhomocysteinemia but also with increased CRP concentrations. Increased plasma concentrations of homocysteine and CRP can be useful in clinical practice to be predictor of long-term prognosis for cardiovascular disease and the treatment of OSA.  

*(CHEST 2006; 129:233–237)*
Table 2—Demonstration of the Whole Parameters Detected in Patients and Control Subjects*

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Group 1 (n = 30)</th>
<th>Group 2 (n = 32)</th>
<th>Control (n = 30)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Homocysteine, μmol/L</td>
<td>21.53 ± 14.2†</td>
<td>7.4 ± 5.12</td>
<td>6.8 ± 4.7</td>
</tr>
<tr>
<td>CRP, mg/L</td>
<td>5.08 ± 3.25‡</td>
<td>2.7 ± 0.60§</td>
<td>1.8 ± 0.61</td>
</tr>
<tr>
<td>Total cholesterol, mg/dL</td>
<td>212.8 ± 46.0‡</td>
<td>197.7 ± 27.0§</td>
<td>118.4 ± 32.2</td>
</tr>
<tr>
<td>Triglyceride, mg/dL</td>
<td>153.8 ± 69.0‡</td>
<td>132.7 ± 65.0§</td>
<td>78.0 ± 18.8</td>
</tr>
<tr>
<td>HDL-C, mg/dL</td>
<td>44.0 ± 10.0</td>
<td>43.2 ± 10.9</td>
<td>47.1 ± 9.4</td>
</tr>
<tr>
<td>LDL-C, mg/dL</td>
<td>133.3 ± 33.3‡</td>
<td>124.6 ± 27.1§</td>
<td>56.4 ± 20.6</td>
</tr>
<tr>
<td>Lipoprotein (a), mg/dL</td>
<td>16.6 ± 11.0‡</td>
<td>13.0 ± 9.3§</td>
<td>8.7 ± 3.2</td>
</tr>
<tr>
<td>Apolipoprotein A-I, mg/dL</td>
<td>126.4 ± 20.6</td>
<td>121.7 ± 39.1</td>
<td>132.1 ± 27.9</td>
</tr>
<tr>
<td>Apolipoprotein B, mg/dL</td>
<td>110.8 ± 33.7†</td>
<td>101.8 ± 23.3‡</td>
<td>80.4 ± 16.7</td>
</tr>
</tbody>
</table>

*Data are presented as mean ± SE.

†Significant difference between group 1 and group 2 (p < 0.05).
‡Significant difference between group 1 and control group (p < 0.05).
§Significant difference between group 2 and control group (p < 0.05).
Management
Management

- Medical management
- Surgical management
- Nonsurgical Treatment
- Behavioral Modification
- Sleep Hygiene for children
Medical management

Pharmacological therapy:

- intranasal corticosteroid
- leukotriene antagonist
Intranasal corticosteroid for adenoid hypertrophy and obstructive sleep apnea

- Beclomethasone
- Fluticasone propionate
- Budesonide
- Momethasone furoate
- Budesonide
Intranasal corticosteroids for moderate to severe adenoidal hypertrophy

Limited evidence suggests that intranasal corticosteroids
1. Significantly improve nasal obstruction symptoms in children with moderate to severe adenoid hypertrophy
2. Improvement may be associated with reduction of adenoid size
3. The long-term effect remains to be defined

Zhang L, Mendoza-Sassi RA, César JA, Chadha NK. Cochrane Database of Systematic Reviews, Issue 1, 2009
16 weeks treatment with montelukast in 24 children with SDB

<table>
<thead>
<tr>
<th></th>
<th>Montelukast</th>
<th>No treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
</tr>
<tr>
<td>A/N ratio</td>
<td>0.76±0.03</td>
<td>0.56±0.03</td>
</tr>
<tr>
<td>Respiratory arousal index</td>
<td>7.2±0.8</td>
<td>3.0±0.3</td>
</tr>
<tr>
<td>Obstructive AHI</td>
<td>3.0±0.22</td>
<td>2.0±0.3</td>
</tr>
<tr>
<td></td>
<td>12 weeks montelukast + intranasal steroids (n = 22)</td>
<td>No treatment (n = 14)</td>
</tr>
<tr>
<td>-------------------------</td>
<td>----------------------------------------------</td>
<td>---------------------</td>
</tr>
<tr>
<td></td>
<td>Pre-treatment</td>
<td>Post-treatment</td>
</tr>
<tr>
<td>Respiratory arousal index</td>
<td>4.6 ± 0.6</td>
<td>0.8 ± 0.3*</td>
</tr>
<tr>
<td>Apnoea index</td>
<td>1.9 ± 0.3</td>
<td>0.1 ± 0.3*</td>
</tr>
<tr>
<td>Obstructive AHI</td>
<td>3.9 ± 1.2</td>
<td>0.3 ± 0.3*</td>
</tr>
<tr>
<td>Nadir SpO₂ (%)</td>
<td>87.3 ± 3.1</td>
<td>92.5 ± 3.0*</td>
</tr>
</tbody>
</table>

AHI: apnoea–hyponoea index; SpO₂: pulse oximetry.
* p < 0.05.
activation of leukotriene inflammatory pathway has been demonstrated in children with OSA

explaining the efficacy of a treatment with montelukast, a leukotriene receptor antagonist, alone or in combination with corticosteroids.
Surgical management

- Adenotonsillectomy
- Tracheostomy
- Maxillofacial plastic surgery
- Uvulopalatopharyngoplasty (UPPP)
Adenotonsillectomy

- mainstay of treatment of OSAS in healthy children.
- Adenotonsillar hyperplasia plays a key role in compromise of airway patency during sleep, and removal of tonsils and adenoids cures OSAS in most children.
- New surgical techniques for removal of tonsils and adenoids or reduction in tonsil size continue to evolve
Table 3
Risk factors for respiratory compromise following adenotonsillectomy for obstructive sleep apnea syndrome (OSAS)

- Age younger than 3 years
- Severe OSAS on polysomnography
- Cardiac complications of OSAS
- Morbid obesity
- Failure to thrive
- History of premature birth
- Congenital heart disease
- Recent respiratory infection
- Neuromuscular disorders
- Craniofacial anomalies
- Chromosomal disorders
Surgical management of obstructive sleep apnea in infants and young toddlers

- Joseph S. Brigance, MD; et.al

Results:
- The surgical treatment group (AHI) improved posttreatment: mean AHI change was 9.6 (95% CI, 5.8-13.4).
- The medical treatment group did not improve posttreatment: mean AHI change was –3.0 (95% CI, –15.1 to 9.1).
- The difference in AHI change between surgical and medical groups was 12.56 (95% CI, 2.7-22.4).

Conclusions
- AHI in the surgically treated group significantly improved.
- complication rate for a tertiary pediatric hospital population that included patients with multiple comorbidities was acceptable.
Uvuloplatopharyngoplasty

- treat snoring or mild OSAS in adults, but reserved for children at high risk for persistent obstruction after adenotonsillectomy.

- UPPP has been used for children with neuromotor disease such as cerebral palsy or with craniofacial anomalies such as Down syndrome.
Figure 1  Technique of uvulopalatal flap combined with tonsillectomy and suturing of the palatal pillars.
Figure 2  Technique of modified hyoid suspension without myotomy using a single-wire suture.
Other pharyngeal surgery

Tongue-reduction procedures:
- treat macroglossia contributing to OSAS, usually in Beckwith-Wiedemann and Down syndromes

Pharyngeal flap revision:
- child who develops persistent OSAS after surgical treatment of velopharyngeal insufficiency
- more common in children born with the Robin sequence (triad of wide soft palate cleft, micrognathia, and glossophthosis)
Craniofacial surgery

- Combinations of mandibular advancement, tongue reduction, tongue-hyoid suspension, and other nasal and pharyngeal procedures have been used to avoid tracheotomy in children with OSAS associated with cerebral palsy, Down syndrome, hemifacial microsomia, and other disorders.
Tracheotomy

- Indicated for treatment of severe OSAS in children with complicated anatomic or neuromotor issues
- The aforementioned procedures are ill advised, when surgical efforts have failed, or when nasal continuous or bilevel positive airway are not helpful or are impractical.
Figure 1. Illustration of many anatomical abnormalities in a 7-year-old child, including asymmetry of the nares, an enlarged septal base, large medial crus, deviation of the septum to the right, and a narrow and high-arched palate. **rapid maxillary distractor** has been placed to widen the maxillary cavity, decrease the height of the soft palate, and enlarge the bony aspects of the nose.
Figure 4. Rapid maxillary distraction demonstrates progressive improvement in the crowding of a child’s teeth, from immediately after insertion of the distractor (A) to 3 weeks later (C). Progressive widening is indicated by the space between the 2 frontal incisors.
# Interventions for obstructive sleep apnea in children: A systematic review

Stefan Kuhle a,1; et.al

Sleep Medicine Reviews (2009) 13, 123e131

## Table 2: Efficacy of interventions for OSA (primary and secondary outcomes), expressed as post-treatment mean difference and relative risk, respectively, with 95% confidence interval

<table>
<thead>
<tr>
<th>Comparison</th>
<th>Participants</th>
<th>Statistical method</th>
<th>Effect size (95% CI)</th>
</tr>
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<tbody>
<tr>
<td>Intranasal steroids vs. placebo&lt;sup&gt;25&lt;/sup&gt;</td>
<td>n = 25</td>
<td>MD</td>
<td>-7.30 [-15.57, 0.97]</td>
</tr>
<tr>
<td>Apnea/hypopnea index</td>
<td>MD</td>
<td></td>
<td>-2.50 [-7.67, 2.67]</td>
</tr>
<tr>
<td>Oxygen desaturation index</td>
<td>MD</td>
<td></td>
<td>-1.20 [-5.24, 2.84]</td>
</tr>
<tr>
<td>Respiratory arousal index</td>
<td>MD</td>
<td></td>
<td>-1.90 [-5.98, 2.18]</td>
</tr>
<tr>
<td>Nadir of SpO&lt;sub&gt;2&lt;/sub&gt;</td>
<td>MD</td>
<td></td>
<td>0.00 [-0.83, 0.83]</td>
</tr>
<tr>
<td>Mean SpO&lt;sub&gt;2&lt;/sub&gt;</td>
<td>MD</td>
<td></td>
<td>1.62 [0.63, 4.16]</td>
</tr>
<tr>
<td>Avoidance of ATE</td>
<td>RR</td>
<td></td>
<td>-2.90 [-5.25, -0.55]</td>
</tr>
<tr>
<td>Clinical symptom score</td>
<td>MD</td>
<td></td>
<td>1.85 [0.74, 4.58]</td>
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<tr>
<td>Decrease in tonsillar size</td>
<td>RR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TCRF treatment vs. standard ATE&lt;sup&gt;23&lt;/sup&gt;</td>
<td>n = 23</td>
<td>MD</td>
<td>3.00 [-1.39, 7.39]</td>
</tr>
<tr>
<td>RDI</td>
<td>MD</td>
<td></td>
<td>0.10 [-0.85, 1.05]</td>
</tr>
<tr>
<td>Snoring score</td>
<td>MD</td>
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</table>

Abbreviations: ATE, adenotonsillectomy; MD, mean difference; RR, relative risk; TCRF, temperature-controlled radiofrequency ablation.

A negative value (MD) or a value >1 (RR), respectively, favors the intervention. Insufficient data were provided in the remaining three studies<sup>17,24,26</sup> to determine the effect size estimates.
Practice points

1. Adenotonsillectomy is widely accepted first-line intervention for OSA in children.

2. Most of non-surgical interventions for OSA in children have not been compared against adenotonsillectomy.

3. Non-surgical interventions for OSA in children, nasal steroids are promising candidates. Potential side effects of steroids, such as growth or adrenal suppression, need be considered.
Nonsurgical Treatment

- **NIPPV (CPAP, BiPAP)**
  - Mechanical stenting of upper airway, ↑ FRC
  - Surgical contraindication, persistence apnea, high risk patients
  - Must be titrated in sleep lab  
    [Marcus et al 1995]
  - Well tolerated in older children  
  - Young children – desensitization  
    [Rains et al 1995]
Subject demonstrating the principle of nasal CPAP. The flow generator (a) delivers air through a smooth tube (b) to the mask (c) from which the air is vented (d) generating pressure in the mask which is transmitted to the upper airway.

Neuropsychiatric Disease and Treatment 2006:2(3)
<table>
<thead>
<tr>
<th>Source</th>
<th>Type of Study</th>
<th>PSG</th>
<th>Conclusions</th>
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<tr>
<td>Guilleminault et al, 1986</td>
<td>Feasibility study of 5 children in hospital; prospective 10-mo home study of 5</td>
<td>Before, during titration, and during</td>
<td>Feasibility with parent training; 4 of 5 infants daily use of CPAP at 10-mo;</td>
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<tr>
<td></td>
<td>children</td>
<td>follow-up</td>
<td>follow-up</td>
</tr>
<tr>
<td>Waters et al, 1995</td>
<td>Retrospective review of 80 children</td>
<td>For diagnosis and titration</td>
<td>86% of parents completed training; 12.5% dropped out</td>
</tr>
<tr>
<td></td>
<td>aged 12 d to 15½ y</td>
<td></td>
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</tr>
<tr>
<td>Marcus et al, 1995</td>
<td>Retrospective study of 94 children aged 3-12 mo; applied after adenotonsillectomy in 76%; first treatment in 23 children</td>
<td>For diagnosis and titration</td>
<td>1 Dropout</td>
</tr>
<tr>
<td>Guilleminault et al, 1995</td>
<td>Prospective study of infants aged 8-18 wk at entry and systematic follow-up for</td>
<td>For diagnosis, treatment, and each</td>
<td>Need to readjust equipment and pressure on regular basis owing to fast craniofacial growth in infancy</td>
</tr>
<tr>
<td></td>
<td>12 mo; family underwent screening at entry for understanding of treatment</td>
<td>follow-up retitation</td>
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<tr>
<td>Rains, 1995</td>
<td>Prospective study of 4 children aged 3-12 y; training of parents</td>
<td>For diagnosis and titration</td>
<td>Follow-up for 3 mo; effective treatment; no dropout for 3 mo; 1 dropout thereafter</td>
</tr>
<tr>
<td>McNamara and Sullivan, 1999</td>
<td>Prospective study of 24 infants aged 6-51 wk for 12 mo</td>
<td>For diagnosis, titration, and regular</td>
<td>Family training and support; continuous use in 18 children; effective treatment</td>
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<tr>
<td>Downey et al, 2000</td>
<td>Retrospective study of 18 children aged &lt;2 y</td>
<td>follow-up</td>
<td>12 Children successfully treated</td>
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</table>
Clinical Guidelines for the Manual Titration of Positive Airway Pressure in Patients with Obstructive Sleep Apnea

Positive Airway Pressure Titration Task Force of the American Academy of Sleep Medicine

Task Force Members: Clete A. Kushida, M.D., Ph.D., RPSGT (Chair); et.al

Stanford University Center of Excellence for Sleep Disorders, Stanford, CA; et.al

Journal of Clinical Sleep Medicine, Vol. 4, No. 2, 2008
Note: Upward titration at ≥ 1-cm increments over ≥ 5-min periods is continued according to the breathing events observed until ≥ 30 min without breathing events is achieved.
CPAP Titration Algorithm for Patients ≥12 years During Full- or Split-Night Titration Studies

Recommended maximum 20 cm H₂O

The patient may be transitioned to BPAP if there are continued breathing events at 15 cm H₂O**

“Exploration” of pressure

Note: Upward titration at ≥ 1-cm increments over ≥ 5-min periods is continued according to the breathing events observed until ≥ 30 min without breathing events is achieved.

≥ 2 obstructive apneas, or
≥ 3 hypopneas, or
≥ 5 RERAs, or
≥ (3 min of loud or unambiguous snoring)

≥ 1 cm H₂O
≥ 5 min

≥ 1 cm H₂O
≥ 3 min

≥ 1 cm H₂O
≥ 5 min

≥ 1 cm H₂O
≥ 10 min

≥ 1 cm H₂O
≥ 15 min in supine REM sleep

≥ 1 cm H₂O

Stop if re-emergence of breathing events

If patient awakens and complains pressure is too high, a lower pressure that the patient reports is comfortable enough to allow return to sleep should be chosen, and resume titration.

Minimum* 4 cm H₂O

≥ 5 min

≥ 5 min without breathing events

Control of breathing events and

Journal of Clinical Sleep Medicine, Vol. 4, No. 2, 2008
BPAP Titration Algorithm for Patients <12 years During Full- or Split-Night Titration Studies

Recommended maximum IPAP 20 cm

- Exploration of IPAP
  - IPAP +5 cm H₂O
    - ≥ 30 min without breathing events
  - IPAP ≥ 1 cm H₂O for apneas, IPAP ≥ 1 cm for other events
    - ≥ 5 min
      - ≥ 1 obstructive apnea, or
        - ≥ 1 hypopnea, or
        - ≥ 3 RERAs, or
        - ≥ (1 min of loud or unambiguous snoring)

Control of breathing events and ≥ 15 min in supine REM sleep

- IPAP ≥ 1 cm H₂O
  - ≥ 10 min
    - IPAP ≥ 1 cm H₂O
      - ≥ 10 min

- IPAP ≥ 1 cm H₂O for apneas, IPAP ≥ 1 cm for other events
  - Minimum* IPAP 8 / EPAP 4 cm H₂O
    - ≥ 5 min
      - ≥ 1 obstructive apnea, or
        - ≥ 1 hypopnea, or
        - ≥ 3 RERAs, or
        - ≥ (1 min of loud or unambiguous snoring)

If patient awakens and complains pressure is too high, a lower IPAP that the patient reports is comfortable enough to allow return to sleep should be chosen, and resume titration

Stop if re-emergence of breathing events

*Minimum pressure for previous night

Journal of Clinical Sleep Medicine, Vol. 4, No. 2, 2008
BPAP Titration Algorithm for Patients ≥12 years During Full- or Split-Night Titration Studies

Recommended maximum IPAP 30 cm H₂O

"Exploration" of IPAP

IPAP +5 cm H₂O

≥ 30 min without breathing events

Control of breathing events and
≥ 15 min in supine REM sleep

IPAP and EPAP ≥ 1 cm H₂O for apneas,
IPAP ≥ 1 cm for other events

≥ 2 obstructive apneas, or
≥ 3 hypopneas, or
≥ 5 RERAs, or
≥ (3 min of loud or unambiguous snoring)

IPAP and EPAP ≥ 1 cm H₂O for apneas,
IPAP ≥ 1 cm for other events

≥ 2 obstructive apneas, or
≥ 3 hypopneas, or
≥ 5 RERAs, or
≥ (3 min of loud or unambiguous snoring)

IPAP and EPAP ≥ 1 cm H₂O for apneas,
IPAP ≥ 1 cm for other events

≥ 5 min

If patient awakens and complains pressure is too high, a lower IPAP that the patient reports is comfortable enough to allow return to sleep should be chosen, and resume titration

Minimum* IPAP 8 / EPAP 4 cm H₂O

≥ 5 min

Stop if re-emergence of breathing events

TIME

*Minimum pressure values are based on individual patient tolerability and can be adjusted as needed.
Mandibular advancement splints (MAS)

Mandibular advancement splints showing both adjustable appliance (a) which uses a hinge to adjust mandibular advancement or one-piece mono-block appliance (b) with fixed mandibular advancement.
Behavioral Modification

- Avoidance of tobacco smoke, indoor allergen & pollutants
- Weight loss
- Sleep position
- Sleep Hygiene
Sleep Hygiene for children

- Follow a consistent routine
- Establish a relaxing setting at bedtime
- Don’t substitute television-watching or videos for personal interaction at bedtime
- Screen television programs, videos and computer games for age appropriate material
- Avoid letting the child fall asleep with a bottle or with nursing, being held or roofed
- Avoid food and drinks containing caffeine (chocolate, coke, etc.)
Follow up
SLEEP DISTURBANCE
During the past 4 weeks, how often has your child had...
...loud snoring?
...breath holding spells or pauses in breathing at night?
...choking or gasping sounds while asleep?
...restless sleep or frequent awakenings from sleep?

PHYSICAL SUFFERING
During the past 4 weeks, how often has your child had...
...mouth breathing because of nasal obstruction?
...frequent colds or upper respiratory infections?
...nasal discharge or runny nose?
...difficulty in swallowing foods?

EMOTIONAL DISTRESS
During the past 4 weeks, how often has your child had...
...mood swings or temper tantrums?
...aggressive or hyperactive behavior?
...discipline problems?

DAYTIME PROBLEMS
During the past 4 weeks, how often has your child had...
...excessive daytime drowsiness or sleepiness?
...poor attention span or concentration?
...difficulty getting out of bed in the morning?

CAREGIVER CONCERNS
During the past 4 weeks, how often have the above problems...
...caused you to worry about your child's general health?
...created concern that your child is not getting enough air?
...interfered with your ability to perform daily activities?
...made you frustrated?
แบบสอบถามเพื่อวัดคุณภาพชีวิต เพื่อประเมินภาวะหายใจผิดปกติขณะหลับ

ติ่ง匿名 สำหรับคำถามต่อไปนี้

กรุณาช่วยตอบกลับด้วยผลที่ใกล้เคียงกับความรู้สึกของอาการหรือปัญหาที่เกิดขึ้นกับลูกของท่านในช่วง 4 สัปดาห์ที่ผ่านมา
( หรือตั้งแต่การสอบถามครั้งที่แล้วมาถึงเวลาบ่ายวันนี้ ) ขอบคุณ

<table>
<thead>
<tr>
<th>อาการของลูกของนายท่าน</th>
<th>ไม่เกิดขึ้นเลย</th>
<th>เกิดขึ้นบางครั้ง</th>
<th>เกิดขึ้นบ่อยพอควร</th>
<th>เกิดขึ้นบ่อยมาก</th>
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อาการทางร่างกายของลูกของนายท่าน:

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<th>เกิดขึ้นบางครั้ง</th>
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หมายเหตุ: สำหรับคำถามต่อไปนี้ กรุณาเขียนวงกลมรอบหมายเลขที่ใกล้เคียงกับความรู้สึกของอาการหรือปัญหาที่เกิดขึ้นกับลูกของท่านในช่วง 4 สัปดาห์ที่ผ่านมา (หรือตั้งแต่การสอบถามครั้งที่แล้วมาถึงเวลาบ่ายวันนี้). ขอบคุณ
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</tbody>
</table>

หมายเหตุ: ตัวเลขที่แสดงผลการวิจัยให้ความคิดเห็นว่า 1 = ไม่เกิดขึ้นเลย, 2 = บางทีไม่เกิดขึ้น, 3 = เกิดขึ้นน้อยมาก, 4 = เกิดขึ้นบ้างบางครั้ง, 5 = เกิดขึ้นบ่อยพอควร, 6 = เกิดขึ้นบ่อยมาก, 7 = ตลอดเวลา