Complications of Sleep-Disordered Breathing
Similarities between Pediatrics and Adults

CATHERINE KIER, MD
Professor of Clinical Pediatrics
Division Chief, Pediatric Pulmonary, and Cystic Fibrosis Center
Director, Pediatric Sleep Disorders Center
SUNY Stony Brook
No disclosures
Objectives:

At the end of this session, the participant would be able to:

• Discuss the similar complications of sleep disordered breathing including obesity, cardiovascular and neurologic dysfunction and explain how these manifestations may differ in adults compared to children

• Identify prevention strategies to avoid these complications and discuss the different approaches between pediatric and adult management of sleep disordered breathing
### OSA estimated prevalence

**Pediatrics**
- parent-reported questionnaire: 4 to 11%
- diagnostic studies: 1 to 4%
- snoring by any definition (meta-analysis): 7.45%

**Adults**
- diagnostic studies: (AHI ≥15 events per hour; or AHI ≥5 with at least one clinical symptom)
  - 15% (males)
  - 5% (females)

## OSA – epidemiology

### Pediatrics
- **race:** African American
- **age:** peak prevalence between 2 and 8 years
- **gender:** boys > girls
- **Second cohort:**
  - Obese adolescents

### Adults
- **race:** African Americans who are younger than 35 years old
- **age:** increases from young adulthood through 6\textsuperscript{th} to 7\textsuperscript{th} decade
- **gender:** males (2 to 3 times) > females
- **gap narrows at age of menopause**

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Prevalence of OSA in the US increasing due to rising rates of obesity.
OSA – risk factors

**Pediatrics**
- Adenotonsillar hypertrophy
- Obesity
- recurrent otitis media and sinusitis, asthma
- smoke exposure and maternal smoking during pregnancy
- prematurity; delayed motor milestones
- prenatal and perinatal stressors

**Adults**
- Obesity
- Craniofacial and upper airway abnormalities
- nasal congestion
- smoking
- menopausal and postmenopausal
- substances and medications
  - Alcohol, narcotics, benzodiazepines


JAMA. 2004;291(16):2013
# OSA – medical conditions

<table>
<thead>
<tr>
<th>Pediatrics</th>
<th>Adults</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Cerebral palsy</td>
<td>• Pregnancy</td>
</tr>
<tr>
<td>• Down syndrome</td>
<td>• Congestive heart failure</td>
</tr>
<tr>
<td>• Craniofacial anomalies</td>
<td>• End-stage renal disease</td>
</tr>
<tr>
<td>• Orthodontic problems</td>
<td>• Chronic lung disease</td>
</tr>
<tr>
<td>• History of low birth weight</td>
<td>• Stroke and transient ischemic attacks</td>
</tr>
<tr>
<td>• Neuromuscular disorders</td>
<td>• Acromegaly</td>
</tr>
<tr>
<td>• Metabolic and storage diseases</td>
<td>• Hypothyroidism</td>
</tr>
<tr>
<td>• Achondroplasia</td>
<td>• Polycystic ovary syndrome</td>
</tr>
<tr>
<td>• Prader-Willi syndrome</td>
<td>• Craniofacial and upper airway abnormalities</td>
</tr>
</tbody>
</table>

## OSA symptoms

### Pediatrics

**Nighttime symptoms**
- Snoring/witnessed apnea, mouth breathing, choking/gasping, sweating, restless sleep, agitated sleep, sleeping in unusual positions (hyperextended neck)
- Parasomnias may be associated with OSA
  - Sleep terrors, sleep walking, or confusional arousals
- Nocturnal enuresis

### Adults

**Nighttime symptoms**
- Snoring, restlessness, or resuscitative snorts
- The bed partner reports loud snoring, or interruptions in breathing while sleeping

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## OSA symptoms

### Pediatrics

<table>
<thead>
<tr>
<th>Daytime symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>• mouth breathing and hyponasal speech</td>
</tr>
<tr>
<td>• headache in the morning</td>
</tr>
<tr>
<td>• EDS may be less obvious than in adults</td>
</tr>
<tr>
<td>• age-inappropriate daytime napping, complaints of sleepiness, or falling asleep in school, on short car rides, or on the school bus</td>
</tr>
</tbody>
</table>

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### Adults

<table>
<thead>
<tr>
<th>Daytime symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Excessive daytime sleepiness (EDS)</td>
</tr>
<tr>
<td>• Fatigue</td>
</tr>
<tr>
<td>• Poor concentration</td>
</tr>
</tbody>
</table>

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# OSA physical findings

## Pediatrics

**Findings**

- may be obese or grow poorly
- tonsil size
- Craniofacial anomalies
- Adenoid facies
  - Decreased nasal airflow, hyponasal speech
- Mucosal or turbinate swelling
  - other allergic manifestations, such as dark circles under the eyes, swollen eyes, or a transverse nasal crease.

## Adults

**Common findings**

- Obesity
- Crowded oropharyngeal airway
- large neck circumference
- hypertension

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• Micrognathia/retrognathia

Significant overbite suggests a small jaw, which may be due to abnormal maxillomandibular development.
• High-arched and narrow hard palate
• Overlapping incisors
Tonsils and adenoids

- Most common cause of upper airway obstruction is lymphoid hypertrophy (of tonsils and adenoids)
Tonsillar Size
Evaluation of adenoids

Laryngoscopy

Lateral Neck Film
FIGURE 1 - Patient with severe OSAS. Craniofacial and cervical morphology demonstrating a Class II standard with mandibular bony base involvement, short neck, widened cervical circumference and excess fat in the submental region.
## OSA polysomnographic features

### Pediatrics
- Obstructive apneas, hypopneas, respiratory effort related arousals (RERAs) – airflow limitation
- Obstructive hypoventilation common in young children
  - Continuous partial collapse the airway
  - Increased upper airway resistance
  - Hypoventilation (hypercapnia)

### Adults
- Obstructive apneas (more discrete), hypopneas, or RERAs

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The spectrum of sleep disordered breathing in children

- Normal
- Primary Snoring (PS)
- Upper Airway Resistance Syndrome (UARS)
- Obstructive Hypoventilation (OH)
- Obstructive Sleep Apnea Syndrome (OSAS)

- O2 desaturations
- ETCO2
- Respiratory arousals
- Airflow alteration
- Snoring
### Severity of OSA based on PSG guidelines

<table>
<thead>
<tr>
<th></th>
<th>AHI (per hour)</th>
<th>O₂ saturation nadir</th>
<th>ECO₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>0-1</td>
<td>&gt;92%</td>
<td></td>
</tr>
<tr>
<td>Mild OSA</td>
<td>2-4</td>
<td></td>
<td>ECO₂ &gt;50 mmHg for 10-24% TST</td>
</tr>
<tr>
<td>Moderate</td>
<td>5-9</td>
<td></td>
<td>ECO₂ &gt;50 mmHg for 25-49% TST</td>
</tr>
<tr>
<td>Severe</td>
<td>&gt;10</td>
<td>&lt;80%</td>
<td>ECO₂ ≥50 mmHg for &gt;50% TST</td>
</tr>
</tbody>
</table>
Guide for remembering severity of OSA in children in comparison to adults

**Spectrum:**

- **Children AHI index**

<table>
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<td>0-1</td>
<td>2-4</td>
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<td>&gt;10</td>
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- **ECO2 in children (>50 mm Hg in TST)**

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<tr>
<td>&lt;10%</td>
<td>10-24%</td>
<td>25-49%</td>
<td>&gt;50%</td>
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</table>

- **Adults AHI index**

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<th>Normal</th>
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<th>Moderate</th>
<th>Severe</th>
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<tbody>
<tr>
<td>&lt;5</td>
<td>5-15</td>
<td>15-30</td>
<td>&gt;30</td>
</tr>
</tbody>
</table>
OSAS – complications

<table>
<thead>
<tr>
<th>Pediatrics</th>
<th>Adults</th>
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<tbody>
<tr>
<td>• Cardiovascular</td>
<td>◆ Cardiovascular risk factors</td>
</tr>
<tr>
<td>• Growth</td>
<td>◆ Metabolic syndrome</td>
</tr>
<tr>
<td>• Neurobehavioral abnormalities</td>
<td>◆ Cognitive deficits</td>
</tr>
<tr>
<td>• Inflammation</td>
<td>◆ Surgical risk</td>
</tr>
<tr>
<td></td>
<td>◆ Quality of life</td>
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</table>


Sleep. 2013;36(9):1297
OSA and cardiovascular disease - ADULTS

- hypertension
- coronary heart disease
- cardiac arrhythmia
- heart failure
Fight and flight

- an interruption of normal sleep architecture
- alterations in physiologic gas exchange
  - repetitive decreases in oxygen saturation followed by rapid re-oxygenation
  - episodic hypercapnia
- occlusion of the upper airway
  - large fluxes in intrathoracic pressure
  - recurrent brain arousals
- induces potent and sustained activation of sympathetic nervous system
SDB in Atrial Fibrillation (AF)

- Sleep disordered breathing is recognized as a notable factor in atrial fibrillation
- Moderate to severe SDB has been shown to adversely affect LV diastolic function in candidates for AF ablation.
Stress hormones

- Breathing rate increases
- Blood flow to skeletal muscles increases
- Intestinal muscles relax
- Heart rate increases
- Blood pressure in arteries increases
- Blood sugar levels increase
- Pupils dilate
Pathophysiology

- repetitive episodes of apnea or reduced inspiratory airflow
- significant increase in sympathetic activity
- heart rate and blood pressure

**Different mechanisms:**

- chemoreflex stimulation by hypoxia and hypercapnia
- baroreflexes
- pulmonary afferents
- impairment in venous return to the heart
- alterations in cardiac output and the arousal response
- endothelial dysfunction
Autonomic dysfunction in OSA

• Why is OSA linked to hypertension?
  • elevated levels of plasma and urinary catecholamines
  • lack of the normal pattern of reduction of blood pressure during sleep (i.e., a nondipping blood pressure)

Circulation. 1999 Dec;100(23):2332-5
Clinical evidence

• increased prevalence of hypertension in OSA
  • Even after controlling for confounding factors (age and obesity)
• Consistent findings in cross-sectional population-based studies
  • BMJ. 2000;320(7233):479.
Memory and OSA - Adults

- Memory impairment
- Lack of concentration
- Even depression and anxiety

Cardiovascular dysfunction

- blood pressure
- echocardiographic findings
  - left ventricular dysfunction
  - increased pulmonary pressures
  - end-diastolic dysfunction
- autonomic functions
- inflammatory markers
  - C-reactive protein
  - N-terminal pro–B-type natriuretic peptide
Blood pressure in pediatric OSA

- blood pressure and heart rate changes during obstructive events (similar in magnitude in adults) (O’Driscoll, 2009)
- a strong, dose-dependent relationship between elevated BP and severity of SDB (Li, 2004; Amin 2004, 2008)

Children with severe OSA have significantly greater mean BP during wakefulness and sleep.
• Hypertension
Intermittent hypoxemia

- in critical stages of development, augment effects of systemic inflammation and metabolic alterations
  - diabetes and vascular disease risks in later life
- Epidemic of obesity: 1 of 3 children may be at risk for developing diabetes
Neurocognitive Dysfunction-Pediatrics

- even children with primary snoring
  - performance deficits compared with controls (attention, overall cognitive functioning, language, and visuospatial abilities) (O’Brien 2003, 2004)

- impairments in neuropsychological functioning may be result of sleep or gas exchange abnormalities (Khadra, 2008; Gozal 2010)
• Reasonable: children with learning or attention problems or poor academic functioning
→ should be evaluated for SDB in the clinical setting
• Poor academic performance
  • first graders lowest 10th percentile with 18% of significant SDB symptoms (Gozal D. Pediatrics 1998;102:616–620.)

• High scores on hyperactivity scales
ADHD and SDB

• overlap between ADHD and SDB
  • 25% of children with ADHD also had SDB symptoms (i.e., snoring) (Chervin, Sleep 2001;24:313–320)
  • 28% of children scheduled for T and A meet the DSM-IV-R criteria for ADHD (Dillon, J Am Acad Child Adolesc Psychiatry 2007;46:1425–1436.)
  • 50% of those children no longer met ADHD criteria one year post-operatively
First line treatment

**Adenotonsillectomy**

- Adenotonsillectomy is first line therapy for otherwise healthy children who have OSA and adenotonsillar hypertrophy
- Alternatives
  - Watchful waiting
  - CPAP
  - Intranasal steroids
  - Weight loss

**CPAP**

- Positive airway pressure therapy is the mainstay of therapy for adults with OSA
- Alternatives
  - Oral appliance
  - Upper airway surgery
  - Pharmacologic
  - Weight loss
RME versus oral appliance

**Pediatrics**
- RME (rapid maxillary expansion) or Palate expander
  - From age 8 years up to pubertal period

**Adults**
- mandibular advancement splints
- tongue retaining devices
Rapid maxillary expansion

• What is RME?
  • orthodontic appliance deliver a lateral force to the upper posterior molars, opens the midpalatal suture transversely and therefore widens the nasal cavity
Bimaxillary Expansion Therapy

• A form of RME
• Procedure involves screw-activated expansion devices that is installed onto the dentition
• Shows promise as a treatment option for refining respiratory parameters in pediatric sleep-disordered breathing
Oral appliance
Medical Burden and Age

• Medical burden and severity of sleep disorders increase significantly with age
• Sleep wake symptoms decreased with age (daytime drowsiness, insomnia, fatigue)
• Advancing age may be associated with a decrease in symptom awareness
Summary

- Adults
- Adverse outcomes include excessive daytime sleepiness, inattention, fatigue, and cardiovascular morbidities such as resistant systemic hypertension
- severe untreated OSA (ie, AHI >30 events per hour) at increased risk for all-cause mortality
Summary

- Pediatrics
- Inattention, learning problems, and behavioral problems (eg, hyperactivity, impulsivity, rebelliousness, and aggression) associated with OSA in children.
- Excessive daytime sleepiness is also associated with OSA, but may not be present, especially in young children..
Similarities - Pediatrics and Adults

• blood pressure and heart rate changes during obstructive events (similar in magnitude in pediatrics and adults)
• adolescents with SDB
  • 6.5-fold higher risk of metabolic syndrome
• emergence of a phenotypic variant of OSA in children and adolescents
  • closely resembles that of adults with the disease
• significant effects on attention, cognitive functioning, memory and general intellectual abilities