Respiratory Disorders During Sleep In Children

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Objectives

• **Provide an understanding of normal sleep development in children and adolescents.**

• **Define sleep disordered breathing in children.**

• **Review clinical presentation and screening tools in resource limited countries.**

• **Review treatment options for obstructive and nonobstructive sleep apnea in children.**
INTRODUCTION

- The average child spends almost half of his or her life asleep
- Newborns can sleep as much as 16 hours per day
- Respiratory disorders during sleep are thus of special importance during childhood

WHAT IS SLEEP AND WHY DO WE NEED IT?

- If sleep does not serve an absolutely vital function, then it is the biggest mistake the evolutionary process ever made. (Rechtschaffen)

- What happen when sleep deprived:
  - Total (REM + NREM) Sleep Deprivation (animals)
    - Brownish/disheveled fur, Skin lesions on tails/paws, Increased food intake but 20% weight loss and death in 11-32 days (avg = 20)

- Following sleep deprivation: One-third of total sleep time lost is made up
  - All of slow-wave (deep NREM) sleep
  - 50% of REM sleep

We do need sleep to function
The Amount of Sleep Children and Adolescents Need

Mean duration of TST
6 months: 14.2±2.5h
1 year: 13-14 h
3 years: 12-13 h
6 years: 11 h
16 years: 8.1 ±0.8 h

493 children: study at 1, 3, 6, 9 12, 18, 24 months, and every year until 16 years

Iglowstein et al. Pediatrics 2003
The two-process model of sleep-wake regulation

- Sleep homeostasis [Process S]
- Circadian process [Process C]
Sleep Homeostasis

- The compensatory response to sleep loss
- The tendency to sleep longer and more deeply after sleep deprivation.
- There is more slow wave sleep after sleep deprivation
- Chronic partial sleep loss leads to an increase in the homeostatic drive to sleep – this is why we sleep more on weekends.
- Adenosine may play an important role in the physiologic drive to sleep
- Sleepiness exhibits circadian variation

- The primary role of the human circadian pacemaker is to promote wakefulness during the day so that sleep can be consolidated at night.

- There is a biphasic circadian rhythm to sleep propensity
  - There is a midday increase in sleep tendency (3-4 PM) followed by a decrease in sleep tendency and increased alertness through early and mid-evening hours
THE STAGES OF SLEEP

NREM
- “Quiet” sleep
- Divided into Stages 1-3

REM
- “Active” sleep
- Associated with dreaming
NREM – or non-REM sleep

• Divided into stages

• Stage 1 (3-8% of total sleep time) is a transition sleep.

• We spend most of our time in Stage 2 sleep (45-55% of total sleep time)

• Stages 3 is “deep” sleep (15-20% of TST)
  • Restorative
  • First to be “made up” after sleep deprivation
NREM SLEEP: Stage 1

- > 50% of the epoch contains Theta activity (3-7 cps.)
- Slow rolling eye movements in the EOG channels
- Relatively high submental EMG tone
NREM SLEEP: Stage 2

- Rolling eye movements stop and muscle tone decreases a bit more
- K-Complexes and Spindles occur episodically
- Mirrored EEG in the EOG leads
NREM SLEEP: Stage 3

- Characterized by delta waves – less than 2 hertz and $\geq 75 \, \mu V$
- The EOG leads will mirror all of the Delta EEG Activity
- Submental EMG activity will be slightly reduced from that of light sleep
REM SLEEP

- Rapid eye movements
- Mixed frequency EEG
- Low tonic submental EMG

- In newborns: 60-70% of total sleep time, ↓ with age
- Characterized by jerks, grimaces, “smiles,” eye movements, blinking.
- REM tends to “concentrate” towards the last half of our sleep cycle.
Sleep in Newborns

- **Active sleep** is the equivalent of subsequent REM sleep
  50-60% of TST

- **Quiet sleep** is the equivalent of non-REM sleep
  30-40% of TST
Sleep Dysfunction in Children: Conceptual Framework

Restricted Sleep (Insufficient *Quantity*)

Disrupted Sleep (Poor Sleep *Quality*)

**Excessive Daytime Sleepiness**

Primary Disorders of Excessive Daytime Sleepiness

Circadian Rhythm Disorders
My 3-month-old doesn’t sleep through the night.

"There are four reasons for him to cry... he's hungry, he's wet, a pin is sticking him, or he wants to wake you up from a sound sleep."
SLEEP AND BREATHING DISORDERS IN INFANTS

- Sudden Infant Death Syndrome
- Apparent Life Threatening Event
- Periodic breathing
- Apnea of prematurity
- Congenital central hypoventilation syndrome
Sudden Infant Death Syndrome

- Not considered sleep disordered breathing
- By definition within the first year of life
- Etiology unclear
- Prevalence: 0.57/1000 live births (2002)
- Leading cause of infant death in developed countries
- Peak age 2-4 months
Sudden Infant Death Syndrome
Risk factors

- Male gender
- Preterm birth
- Low birth weight
- Young maternal age

- High parity
- Smoking/substance abuse
- Late/no prenatal care
- Prone sleep
- Unsafe sleep environment
Apparent Life Threatening Event

- Defined as a witnessed, frightening event
  - Witnessed Apnea
  - Change in tone
  - Change in color
  - +/- Choking

- Occurs in as many as 1-3% of healthy term infants

- Rarely a manifestation of sleep disordered breathing

- Management directed by etiology: GERD, Viral, abuse, infection, arrhythmia, seizure …
Case 1: A 2 month old infant observed by parents to stop breathing during sleep.
Periodic breathing in the newborn

- Three or more episodes of central apneas, each lasting longer than 3 seconds, and separated by continuous respiration of less than 20 seconds.

- There may or may not be significant desaturations with the events.

- It is considered a benign condition in infants and frequently observed in preterm infants.

- It is not a precursor of significant apnea and usually decreases with increased gestational age.
Central Apnea  These are central apneas (2) with minimal oxygen desaturation. Notice the low SAO2 at the beginning of this tracing. This is associated with a previous apnea.

Both of these events range between 13-16 seconds in duration.
Obstructive Apnea: A complete blockage of the airway despite efforts to breathe. Notice the effort gradually increasing ending in airway opening.

Blood oxygen levels reduce to < 3% of baseline value.
Hypopnea  This is an 18 second hypopneic event. The airflow signal is reduced by approximately 50% during this event.
Periodic breathing in the newborn

- It is believed to be secondary to immaturity in chemoreceptor function and central control of breathing.

- It is more prevalent in active sleep compared with quiet sleep, and is increased during fever, with significant GE reflux, with high ambient temperature, and at high altitude.

- It responds to methylxanthines and low-flow supplemental oxygen.

- Indications for treatment include: associated heart decelerations, oxygen desaturations, or prolonged periods exceeding 4-10% of total sleep time.
Apnea of prematurity

- Excessive periodic breathing with pathologic apnea in preterm infants

- Pathologic apnea
  - > 20 sec
  - < 20 sec with bradycardia (<30 bpm) or desaturation (<85% for > 5 sec)

- Treatment: Methylxanthines, CPAP, O2, Mechanical ventilation
A Full Term Infant with Cyanotic Episodes

- A sleep evaluation was requested for a full-term female infant, 2 weeks of age with no perinatal problems.

- Episodes of cyanosis (with SaO2 as low as 60%) occurring only during sleep.

- During these episodes the infant was noted to breathe shallowly without an increase in respiratory rate until aroused by the caregiver.

- During wakefulness the infant had a normal oxygen saturation of 96%-98%.
  - Physical examination: Normal for age while awake.

- Laboratory evaluation:
  - A CXR, EKG, Echocardiogram, and fluoroscopy of the diaphragm were all normal.
  - A MRI showed no brainstem abnormalities.
  - Screening studies for inborn errors of metabolism were negative.
Thirty-second tracings during wakefulness (left) and NREM sleep (right)
Congenital Central Hypoventilation Syndrome

- Rare 1 per 200,000 live births.
- Alveolar hypoventilation without evidence of lung, neuromuscular, or structural brainstem abnormalities.
- During wakefulness: normal ventilation (except for the most severely affected CCHS)
- Abnormality in the central integration of chemoreceptor
- Mutations in the PHOX2b gene
- Associated autonomic dysregulation: Hirschprung disease, esophageal dysmotility, and Tumors of neural crest origin
A 2 year old with breathing difficulty during sleep

Figure 1: LOC, ROC- ocular channels, C3, C4, O1, O2- EEG, CHIN- EMG, SNORE- snore, ECGL- ECG channel, LAT & RAT- limb movement, PR- pulse rate, OSAT- oxygen saturation, Flow- thermistor flow, CHEST & ABD- chest and abdominal tracings.
A 2 year old with breathing difficulty during sleep

Central apnea

Adults:
absence of inspiratory effort for at least 10 seconds with a drop of thermal sensor excursion by 90% or more.

Children:
absent inspiratory effort that exceeds 20 seconds

or

≥2 respiratory cycles + ≥3% oxygen desaturation or an arousal/awakening.
Case #1

- 3 years old male
- Snoring “since a baby
- No daytime sleepiness
- Restless during sleep and sweats excessively in his sleep
This home video shows a three-year-old boy with OSA
Sleep-disordered breathing (SDB) refers to the clinical spectrum of repetitive episodes of complete or partial obstruction of the airway during sleep.
Types of Sleep Apnea

**Apnea**: Cessation of airflow at the nose and mouth

- Central Apnea: cessation of airflow associated with absent respiratory effort, due to CNS dysfunction
- Obstructive apnea: cessation of airflow despite continued respiratory effort, due to complete airway obstruction
- Hypopnea: reduction of airflow despite continued respiratory effort, due to partial airway obstruction
- Mixed Apnea: central apnea followed by obstructive apnea
- Hypoventilation Syndromes: increase in the arterial carbon dioxide (PaCO2) during sleep
Spectrum of obstructive Sleep Disordered Breathing (SDB) in Childhood

Primary Snoring
- No ventilatory abnormalities (hypercapnea, hypoxia)
  “Benign” but may be at risk for OSAS

Obstructive Apnea/Hypopnea
- Partial upper airway obstruction (50% reduction airflow)
  Most common pattern childhood

Hypoventilation obstructive
- 2 respiratory cycles hypercapnea
Prevalence of OSA

**Adults:** 9-24%

Young, New Engl J Med 1993

**Children:** 1-3%

Ali, Arch Dis Child 1993 (England, children 4-5 years)

Gislason, Chest 1995 (Iceland, age 6 months – 6 years)

Redline, AJRCCM 1999 (USA, 2 to 18 yr. of age)

Ethiopia ?  Africa ?
Prevalence of Snoring

- 11% (Ng, Chest 2005, Hong Kong, age: 6-12 yr)
- 12% (Ali, Arch Child Ds 1993, England, Age 4-5 yr.)
- 9% (Gozal, Pediatrics 2000, Portugal, age 6-10 yr.)
- 10% (Teculescu, Pediatric Pulmonol 1992, France, Age: 5-6 yr)
- 34.2% (Alabi, Int J Pediatr Otorhinolaryngol 2012, Nigeria age 4-6)
- Ethiopia (?)
Adenotonsilar hypertrophy is not the sole cause of childhood OSA
Enlarged Adenoids and tonsils

Crouzon

Pierre-Robin

Down Syndrome

Cerebral Palsy

Duchenne

Enlarged Adenoids and tonsils

RESPIRATORY UPPER AIRWAY RESISTANCE

OSAS

MUSCLE TONE

Other genetic factors,...

Marcus Res Physiol 2000
Partial airway collapse

Model of counterbalancing forces that influence airway patency
Adapted with permission from Thach, B. Neuromuscular control of the upper airway. In: Beckerman, R, Brouillette, R, Hunt, C (Eds), Respiratory Control Disorders in Infants and Children, Baltimore, Williams & Wilkins, 1990, p. 47.
Effects of sleep apnea

- Inadequate level of oxygen in the blood
  - (Hypoxemia)

- High concentration of carbon dioxide in the blood
  - (Hypercapnia)

- Sleep disruption
Clinical features which may be associated with sleep apnea

- Nighttime symptoms
- Daytime symptoms
- Symptoms related to complications
Daytime symptoms

- **Sleepiness**
  - Difficulty am waking
  - Complaints of daytime sleepiness
  - Morning headaches

- **Behavioral**
  - Hyperactivity, poor impulse control
  - Aggressiveness
  - Shyness/social withdrawal

- **Cognitive**
  - Attention span problems
  - Learning problems
  - School failure
Nighttime Symptoms

**Frequent**
- Loud, nightly snoring
- Respiratory pauses, snorts, gasps, choking
- Increased respiratory effort/paradoxical breathing
- Restless sleep
- Odd sleep positions, such as hanging over the bed or sleeping upright with the head extended

**Less frequent**
- Bed wetting
- Excessive sweating during sleep
COMPLICATIONS OF SLEEP APNEA

CARDIOVASCULAR COMPLICATIONS

- Heart failure
- ↑ Night Blood Pressure
- ↓ Cardiac Variability
- Pulmonary hypertension

Poor growth

Marcus C Am J Respir Crit Care Med 1998
Amin RS Am J Respir Crit Care Med 2004
Hunt C et Brouillette RT. Pediatr Cardiol 1982,
Amin R et al. Am J Respir Care Med 2002
OSAS: POOR GROWTH
No combination of symptoms/physical findings reliably differentiates OSAS from primary snoring
Investigation of sleep disordered

MOST COMMON
• Sleep observation
• Sleep study

ADDITIONAL
• Chest X-ray
• ECG/Echocardiogram
• Hemoglobin measurement
• Flexible bronchoscopy
• Barium/cine swallow
• CT/MRI
Nocturnal Polysomnography (Sleep Study)

- **EEG** – measures brain waves, for sleep staging, and to detect arousals
- **EOG** – to detect eye movement- used to detect REM sleep
- **EMG** – to detect Movement
- **Airflow signal**
- **Respiratory movements**
- **Oxygenation**
- **Carbon dioxide**
- **ECG**
- **Video recordings**
NOCTURNAL POLYSOMNOGRAPHY
(SLEEP STUDY)

The only diagnostic technique shown to quantitate the sleep abnormalities associated with sleep-disordered breathing.
Management options for sleep Disordered breathing

Nonsurgical

- Wait and reassess (mild)
- Topical steroids/antileukotriene for mild/intermittent problem.
- Nasal CPAP
- Nasopharyngeal tubes
- Oral appliances and orthodontic treatment.

Surgical

- T & A
- Uvulopalatopharyngoplasty (mainly adults)
- Midface advancement
- Anterior tongue reduction
- Mandibular splint
- Tracheostomy (ultimate treatment)

The most suitable treatment option depends upon the particular patient.