

## Chapter 9

# Sleep-Disordered Breathing and Obstructive Sleep Apnea

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### PEARLS

- Apnea–Hypopnea Index
  - AHI <5—Normal, Snoring, or Upper Airway Resistance Syndrome (UARS)
  - AHI 5–15—Mild Sleep Apnea
  - AHI 15–30—Moderate Sleep Apnea
  - AHI >30—Severe Sleep Apnea
- Sleep Syndromes:
  - Snoring
  - Upper airway resistance syndrome: daytime hypersomnolence, normal PSG
  - Obstructive sleep apnea syndrome: daytime hypersomnolence
    - Apnea and hypopnea (AHI >5)
- Definitions:
  - Apneic event: cessation of ventilation for 10 s or longer leading to an arousal
  - Hypopneic event: a decrease in airflow of 30 % with a 4 % decrease in oxygen saturation or a 50 % decrease in airflow with a 3 % decrease in oxygen saturation
  - Respiratory effort-related arousal (RERA): absence of apnea–hypopnea with a 10 s or more duration of progressive negative esophageal pressure leading to an arousal or microarousal
  - Apnea Index (AI): number of apneas in an hour period
  - Respiratory distress index (RDI): number of apneas, hypopneas, and RERAs in an hour. No longer used in defining sleep apnea

### Sleep Physiology

Normal Sleep:

- Non-rapid eye movement (NREM), “quiet” sleep stage:
  - Steady, slow heart rate
  - Slow respiratory rate
  - Low blood pressure
- Rapid eye movement (REM)
  - Bursts of rapid conjugate eye movement
  - Increased autonomic activity
  - Large fluctuations in heart rate, respiratory rate, blood pressure
  - Dreaming

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**TABLE 9.1** Sleep architecture of young healthy adult

Stage	Arousal threshold		EEG pattern	Sleep distribution (%)
NREM sleep	N1	Low	Theta waves	2–5
	N2	High	K complex/sleep spindles	45–55
	N3	Higher	Delta waves (“slow-wave sleep”)	5–20
REM sleep	Variable		Sawtooth waves	20–25

- Age Distribution
  - Infants and children under age 10
    - Higher percentage of REM sleep and stage 3 NREM sleep
  - >10 Years old adults
    - See Table 9.1
  - > 60 Years old
    - Stage 3 diminished, may no longer be present
- Sex distribution
  - With aging, women maintain slow-wave sleep longer than men

### Obstructive Sleep Disorders

#### Definitions:

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- Patterns of arousal
  - Obstructive: lack of airflow despite ventilatory effort
  - Central: lack of airflow resulting from an absence of ventilatory effort
  - Mixed: usually begins as a central apneic event, ends as an obstructive event

#### Snoring:

- An undesirable sound that occurs predominantly during sleep
- Nonapneic snoring can be associated with arousal or sleep fragmentation
- Does imply upper airway resistance

#### Upper Airway Resistance Syndrome:

- Mild sleep-related upper airway system closure
- No true apnea or hypopnea events
- Does lead to arousals, sleep fragmentation, and excessive daytime sleepiness
- Repetitive alpha EEG arousals with sleep fragmentation
- 15 or more RERAs per hour
- More often seen in women, nonobese patients, and young adults

#### Obstructive Sleep Hypopnea Syndrome:

- Daytime hypersomnolence
- Greater than 15 hypopneas per hour
- No apneas

**Obstructive Sleep Apnea Syndrome:**

- Apnea–hypopnea index (AHI) of 5 or more
- Mild: AHI 5–15
- Moderate: AHI 15–30
- Severe: AHI  $\geq 30$

**Physiology of Upper Airway Obstruction**

## Multifactorial interaction

- Collapsible airway
  - Obesity, soft tissue hypertrophy, craniofacial abnormalities, neuromuscular tone
- Pharyngeal dilator muscle relaxation
  - Reflex pathway from the central nervous system fails to maintain pharyngeal patency
- Nasal obstruction can worsen OSA
  - Open-mouth breathing when asleep that can increase upper airway collapsibility and decrease dilator muscle efficacy
  - Mouth breathing leads to a backward rotation of the jaw displacing tongue base posteriorly, lowers hyoid, leads to pharyngeal collapse
  - Increased resistance upstream leading to an increased collapse downstream via loss of nasal reflex

**Symptoms of OSAS**

- Snoring
- Witnessed episodes of gasping or choking
- Frequent movements that disrupt sleep
- Restless sleep
- Fatigue
- Waking feeling tired and unrefreshed regardless of time slept
- Excessive daytime sleepiness
- Forgetfulness
- Irritability
- Sexual dysfunction
- Motor vehicle accidents (MVAs)
- Job-related accidents
- The degree of daytime sleepiness and its impact on quality of life correlate poorly with the frequency and severity of respiratory events

**Consequence of Untreated OSA**

## Increased mortality

## Cardiovascular disease

- Hypertension
  - Likely related to increased sympathetic tone from hypoxemia and frequent arousals
  - Treatment of OSA improves hypertension
  - Apneic event: decreased cardiac output, increased sympathetic nervous system activation, increased systemic vascular resistance
  - Resolution of apneic episode: increased venous return to the right side of the heart leading to an increased cardiac output against the increased vascular resistance, abrupt increase in blood pressure
  - Multiple cycles, eventual increased sympathetic nervous system activation persists
- Coronary artery disease
  - Recurrent apneas can cause acute thrombotic events, secondary to an increase in platelet activation, and chronic atherosclerosis

- Congestive heart failure
  - Increased afterload on an already failing heart leading to reduced cardiac output
  - Release of catecholamines from the apneic event can worsen cardiac function
- Arrhythmia
  - Bradycardia/arrhythmia are the most common seen
  - Bradycardia starts at cessation of respiration followed by tachycardia at the resumption of respiration as a result of the increased sympathetic activity from the hypoxia and arousal
  - Supraventricular tachycardia, premature ventricular contractions, changes in QT interval
- Myocardial infarcts
  - Acute ischemia can occur as a result of a depletion of myocardial oxygen supply during apneic events
- Stroke
  - Cerebral vascular similar stress as cardiac vasculature
  - Apnea leads to decreased systemic pressure and increase in intracranial pressure leading to a decrease in cerebral perfusion, increasing the chance for an ischemic event
  - Fluctuations in cerebral blood flow, increase in atherosclerotic changes to endothelium, increased risk of thrombotic events
- Risk for insulin resistance
- Sudden death
- Pulmonary hypertension

Neurocognitive difficulties

- Problems with attention, working memory and executive function

Increased risk of fatal and nonfatal motor vehicle accidents (MVA)

**Diagnosis**

Common symptoms

- Loud snoring, restless sleep, daytime hypersomnolence
- In women: insomnia, heart palpitations, ankle edema

Screening

- Epworth Sleepiness Scale Score >10
  - 0 = would never doze
  - 1 = slight change of dozing
  - 2 = moderate chance of dozing
  - 3 = high chance of dozing

Situation	Chance of dozing (0-3)
Sitting and reading	
Watching TV	
Sitting inactive in a public place	
As a passenger in a car for an hour without a break	
Lying down to rest in the afternoon when circumstances permit	
Sitting and talking to someone	
Sitting quietly after lunch without alcohol	
In a car, while stopping for a few minutes in traffic	

Rule out other disorders causing fatigue

Examination

- BMI, blood pressure, neck circumference
- Body habitus, size of mandible/maxilla, retrognathia/prognathia, facial character
- Nasal: size, deformity, valve, septum, turbinates, polyps/masses, adenoids
- Oral Cavity/Oropharynx: size/position of tongue, elongated palate/uvula, tonsils, Mallampati score/Friedman classification, dentition, crowding of oral pharynx

- Hypopharynx: size/position of tongue base, lingual tonsillar hypertrophy
- Larynx: mobility of vocal cords, masses/polyps
- Neck: size, placement of hyoid, jaw/retrognathia
- Flexible nasolaryngoscopy: awake, asleep, lying down
  - Müller maneuver: nose pinched close with mouth closed, inhale against closed airway examining retropalatal and retrolingual areas for collapse
- Drug-induced sleep videoendoscopy
  - Propofol-induced sleep
  - Evaluate degree of obstruction from lateral pharyngeal folds, retropalatal, retrolingual areas

#### Imaging

- Cephalometric radiograph
  - Inferiorly displaced hyoid, small posterior airway space, long palate
  - Mandibular plane to hyoid distance <21 mm associated with higher success in patients with mild to moderate OSA undergoing uvulopalatopharyngoplasty (UPPP)
- CT Scan
  - Poor sensitivity for OSA
- MRI
  - Also poor sensitivity for OSA but excellent evaluation of soft tissue
- Fluoroscopy
  - Can improve UPPP selection/outcomes
  - Time intensive, radiation exposure
- Nocturnal Polysomnography (PSG): Gold Standard
- Level 1:
  - Electroencephalogram (EEG)
  - Electro-oculogram (EOG)
  - Submental electromyogram (EMG)
  - Electrocardiogram (ECG)
  - Nasal and oral airflow
  - Thoracoabdominal effort
  - Blood oxygen concentration/Oximetry (SaO<sub>2</sub>)
  - Body position
  - Snoring
- Level 2:
  - Unattended study performed in the patient's home, limited by lack of technician to perform hookup
  - Same measures as Level 1
- Level 3:
  - Unattended, same limitations as Level 2
  - Heart rate
  - Airflow
  - Oximetry
  - May underestimate AHI because does not determine sleep versus wake
- Level 4:
  - Unattended
  - 1–2 parameters, including oxygen saturation

#### Treatment

##### Medical

- Conservative/Behavioral Modifications
  - Avoid alcohol, sedatives at bedtime
    - Sedatives can promote deep sleep, make apnea more pronounced, blunt drive to arouse and resume breathing

- Weight loss
- Positional therapy: supine position, tongue falls posteriorly enhancing obstruction
- Bariatric surgery consult for morbidly obese patients
- CPAP (Continuous positive airway pressure): Gold Standard
  - Pneumatic splint, prevents upper airway collapse, constant intraluminal pressure during inspiration and expiration
  - Moderate to severe OSA
    - Reduces AHI, improved subjective and objective sleep measures, quality of life measures, decreased cardiovascular events, decreased MVAs
  - Complicated by patient adherence
    - Compliance considered at least 4 h per night, 5 days/week
- BiPAP
  - Separately adjustable lower expiratory and higher inspiratory PAP: tolerated better by some
- APAP (Autoadjusting PAP)
  - Autotitrate PAP to select an effective level of CPAP to prevent upper airway collapse
  - Pressure changes in response to variations, snoring, impedance
- Oral Appliances
  - Mild to moderate OSA
  - Mobilizes mandible and base of tongue anteriorly, maintains patency of posterior oropharyngeal airway
  - Complicated by tooth/jaw pain, increase in salivation overnight, dry mouth
  - Cost effective but more effective for milder cases
- Medications
  - Insufficient evidence. Theory: increase upper airway dilator muscle tone, increase ventilatory drive, increase cholinergic tone during sleep versus a decrease in percent of REM sleep, decreased airway resistance, decreased surface tension in the upper airway
  - Progesterone: respiratory stimulant
  - Acetazolamide: increases hydrogen concentration in blood
  - Theophylline: increases hypoxic ventilatory drive
  - Protryptiline: reduce REM sleep
  - Oxygen therapy
  - Fluticasone: if allergic rhinitis component
  - Montelukast (Leukotriene receptor antagonist): decreased adenoid size in children with mild OSA
  - Modafinil (Central post alpha-adrenergic receptor): promotes alertness, used to treat narcolepsy and idiopathic hypersomnia, adjuvant for patients on CPAP who continue to experience excessive daytime sleepiness
  - Nasal Strips
    - Can decrease snoring, mouth breathing, sleepiness
    - Can improve UPPP selection/outcomes

Surgical: Determined by the site of obstruction

- Counseling possibility of multiple or staged procedures, possibility of tracheostomy
- Nasal: can reduce CPAP requirements, rarely cures OSA
  - Septoplasty
  - Turbinate surgery
  - Nasal valve repair
  - Sinus surgery
  - Adenoidectomy
- Palatal
  - UPPP with or without tonsillectomy
    - Remove uvula, redundant tissue from the soft palate and anterior tonsillar pillars
    - Posterior tonsillar pillars advanced lateral-cephalad direction
    - Enlarge nasopharyngeal airway in anterior to posterior dimension
    - Risk of nasal reflux temporarily, infection, change in speech

- Transpalatal advancement pharyngoplasty after UPPP if persistent OSA
  - Remove 1 cm of the hard palate, advance the soft palate, secure to tensor aponeurosis
- Expansion sphincteroplasty
  - Variation of UPPP
- Uvulopalatal flap
  - Variation of UPPP
  - Advancement flap, suture uvula and distal soft palatal tissue upward onto soft palate
  - If VPI, procedure is reversible
  - Contraindicated in patients with excessively thick palates or uvulas
- Z-palatoplasty
- Laser-assisted uvulopalatoplasty (LAUP)
  - Primarily for snoring
  - CO<sub>2</sub> laser, 2 vertical cuts in soft palate on either side of uvula, amputate lower two-thirds to three-fourths of the uvula
  - Scar retraction and stiffening of the palate is achieved
- Cautery-assisted palatal stiffening (CAPSO)
  - Remove mucosa off midline of soft palate, induces scar tissue resulting in stiffer palate
- Radiofrequency ablation of soft palate
  - Soft palate coagulation necrosis causes scarring and contraction of tissue, shorter stiffer soft palate
  - Office-based procedure, local anesthesia
- Palate implant
  - Used for snoring
  - 3 to 5 implantable rods inserted into the palate for scar formation
  - Risk of implant extrusion
- Injection snoreplasty
  - Office-based procedure for snoring
  - Inject sclerosing agent (alcohol, sodium tetradecyl sulfate) into midline of soft palate
- Tongue Base
  - Partial midline glossectomy
    - CO<sub>2</sub> laser, electrocautery, plasma knife, coblation
    - Risk of bleeding from lingual artery, hypoglossal nerve injury, hematoma, abscess, dysphagia, taste disturbance
  - Lingualplasty
  - Lingual tonsillectomy
  - Radiofrequency tongue base ablation
    - Four lesions at circumvallate papilla to reduce tissue volume at the tongue base
- Hypopharyngeal
  - Genioglossus advancement
    - More anteriorly positioned tongue with increased tension on the genioglossus
    - Rectangular genioglossus osteotomy with advancement
    - Risk of dental root injury, mandible fracture, hematoma
  - Hyoid myotomy/suspension
    - Hyoid mobilized anteriorly and superiorly via attachment to the mandible or to thyroid cartilage
    - Risk of numbness, infection, seroma, fracture, death
  - Tongue suspension
    - Base of tongue to anterior floor of mouth
  - Maxillomandibular advancement
    - Most effective surgical procedure for OSA
    - Enlarges pharyngeal and hypopharyngeal airway
    - Risk of malocclusion, relapse, nerve paresthesia, nonunion, malunion, temporomandibular joint tenderness, infection

- Tracheotomy
  - Bypass the site of upper airway obstruction
  - Indications: morbid obesity, arrhythmia with apnea, severe apnea with desaturation, cor pulmonale, no response to dietary modifications or CPAP, chronic alveolar hypoventilation

#### Postoperative care

- There is an increased risk of airway compromise from edema, respiratory rate alteration secondary to narcotics, possibility of bleeding and difficulty with intubation
- Repeat polysomnography at 3–4 months postoperatively

### Sleep Disorders

#### Insomnia

- Recurrent difficulty with sleep initiation, maintenance, consolidation, or quality causing daytime dysfunction. May include non-restorative sleep or sleep of poor quality
- Daytime symptoms must include at least one:
  - Fatigue or malaise, cognitive impairment (attention, concentration, or memory), social/vocational difficulty or poor school performance, mood impairment or irritability, daytime sleepiness, reduced motivation or energy, tendency to be accident-prone, headache, muscle tension, gastrointestinal upset, concerns about sleep itself

#### Sleep-Related Breathing Disorders

- Central Sleep Apnea Syndromes
  - Primary central sleep apnea
  - Central sleep apnea due to Cheyne-Stokes breathing pattern (increased risk of CHF)
  - Central sleep apnea due to high-altitude periodic breathing
  - Central sleep apnea due to medical condition not Cheyne Stokes
  - Central sleep apnea due to drug or substance
  - Primary sleep apnea of infancy
- Obstructive Sleep Apnea Syndromes
  - Obstructive sleep apnea, adult
  - Obstructive sleep apnea, pediatric
- Other Sleep-Related Breathing Disorders
  - Sleep apnea/sleep-related breathing disorder, unspecified
  - Obesity-related hypoventilation

#### Hypersomnias of Central Origin

- Subclasses:
  - Narcolepsy
  - Recurrent hypersomnia
  - Klein-Levin syndrome
  - Menstrual-related hypersomnia
  - Idiopathic hypersomnia
  - Behaviorally induced insufficient sleep syndrome
  - Hypersomnia due to medical condition
  - Hypersomnia due to drug or substance

#### Circadian Rhythm Sleep Disorders

#### Parasomnias

- Disorders of Arousal
  - Confusional arousals
  - Sleepwalking
  - Sleep terrors
- Parasomnias usually associated with REM Sleep
  - REM sleep behavior disorder (including parasomnia overlap disorder and status dissociatus)
  - Recurrent isolated sleep paralysis
  - Nightmare disorder
    - Treatment: reassurance, cognitive-behavioral therapy, pharmacologic intervention



- Other Parasomnias
  - Sleep-related dissociative disorders
  - Sleep enuresis
  - Sleep-related groaning (catathrenia)
  - Exploding head syndrome
- Parasomnias Associated with Obstructive Sleep Apnea
  - OSA-induced arousals from REM sleep
  - OSA-induced arousals in NREM sleep
  - OSA-induced cerebral anoxic attacks or nocturnal seizures
  - REM rebound from CPAP use leading to:
    - Confusional arousals
    - Sleepwalking
    - Sleep terrors

#### Sleep-Related Movement Disorders

- Subclasses
  - Restless leg syndrome
    - Rule out iron deficiency
  - Periodic limb movement disorder
    - Treatment: clonazepam and dopamine agonist therapy
  - Sleep-related leg cramps
  - Sleep-related bruxism
  - Sleep-related movement disorder, unspecified
  - Sleep-related movement disorder due to drug or substance
  - Sleep-related movement disorder due to medical condition

#### Isolated Symptoms, Apparently Normal Variants, and Unresolved Issues

- Subclasses
  - Long sleeper
  - Short sleeper
  - Snoring
  - Sleep talking
  - Sleep starts (hypnic jerks)
  - Benign sleep myoclonus of infancy
  - Hypnagogic foot tremor and alternating leg muscle activation during sleep
  - Propriospinal myoclonus at sleep onset
  - Excessive fragmentary myoclonus

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