I have no Conflict of Interest
Objectives

- Participants will gain an understanding of the different types of diagnostic sleep studies, their indications and limitations.
- Participants will gain an understanding of interpreting sleep studies and troubleshooting the results.
- Participants will gain an understanding of the different types of sleep apnea devices available.
Lecture Outline

- Definitions
- Pathophysiology
- Diagnosis
  - History
  - Physical Exam
  - Polysomnogram and Home Sleep Tests
- Treatment
  - CPAP
  - OA
  - Alternative Therapies
- Medicare Considerations
Sleep Apnea

**Apnea/Hypopnea Definition:**
- Repetitive cessation or reduction of airflow during sleep
- Associated with arousals and awakenings
- Results in sleep fragmentation and oxygen desaturations
Types of Sleep Disordered Breathing

- **Apnea**
  - Cessation of airflow ≥ 10 seconds

- **Hypopnea**
  - ↓ airflow ≥30% from baseline lasting ≥ 10 seconds associated with ≥ 4% desaturation

- **Respiratory Event Related Arousal**
  - Repetitive, short arousals caused by the increased work of breathing
Types of Disordered Breathing

- **Obstructive**
  - Collapse of pharyngeal airways during inspiratory effort

- **Central**
  - Respiratory efforts are decreased or absent

- **Mixed**
  - Initial central apnea followed by obstructive apnea
# Apnea Patterns

<table>
<thead>
<tr>
<th></th>
<th>Obstructive</th>
<th>Mixed</th>
<th>Central</th>
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<tbody>
<tr>
<td><strong>Airflow</strong></td>
<td><img src="image1.png" alt="Waveform" /></td>
<td><img src="image2.png" alt="Waveform" /></td>
<td><img src="image3.png" alt="Waveform" /></td>
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<tr>
<td><strong>Respiratory effort</strong></td>
<td><img src="image4.png" alt="Waveform" /></td>
<td><img src="image5.png" alt="Waveform" /></td>
<td><img src="image6.png" alt="Waveform" /></td>
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</table>
Pathophysiology of Obstructive Apnea

Wakefulness

Sleep
Definitions to Know

- **AHI (Apnea Hypopnea Index)** = Apneas + Hypopneas per hour
  - **Mild**: AHI 5-15
  - **Moderate**: AHI 16-29
  - **Severe**: AHI ≥ 30

- **RDI (Respiratory Disturbance Index)** = apneas + hypopneas + RERAs
Meet Mr. Small

- 55 yo male
- h/o HTN, atrial fibrillation
- What symptoms to ask about?

- What physical exam findings are relevant?
Symptoms to review:
- Snoring
- Excessive daytime somnolence
- Witnessed apneas

Physical Exam Findings:
- Obesity
- Big neck
  - ≥ 17” neck – males
  - ≥ 16” neck - females
- Mandible anatomy
- Upper Airway Anatomy
  - Mallinpotti Score
Sleep Apnea Risk Factors

- Increasing age
- Male gender
- Family history
- Alcohol or sedative use
  - Cause myorelaxation $\rightarrow$ collapse of airway
- Smoking
Epworth Sleepiness Scale

- Eight questions
- Subjective assessment of symptoms
- Answered by 0-3 point response
- Measures Chronic daytime somnolence
- Score $>10$ strongly associated with daytime sleepiness; $>15$ marked sleepiness
- May also be used to assess response to treatment
Mr. Small

- Snored “forever”
- Wife complains that he stops breathing
- No symptoms of daily sleepiness- ESS 7
- + Retrognathia and micrognathia
- BMI 37
- Mallinpotti 4
Physical Examination

Structural Abnormalities

- Retrognathia
- Micrognathia

Mallampati Classification

### 1994-1998 vs 2007-2010

#### Men

<table>
<thead>
<tr>
<th>AHI ≥5, ESS score &gt;10</th>
<th>1994-1998</th>
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<td>30–70</td>
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<td><strong>14.3</strong></td>
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<td>50–70</td>
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<td>30–70</td>
<td>3.8</td>
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#### Women

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<thead>
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<th>AHI ≥5, ESS score &gt;10</th>
<th>1994-1998</th>
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<td>30–49</td>
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<td>50–70</td>
<td>6.6</td>
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<tr>
<td>30–70</td>
<td><strong>3.8</strong></td>
<td><strong>5.0</strong></td>
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<td>30–49</td>
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<td>0.79</td>
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<td>50–70</td>
<td>2.6</td>
<td>3.2</td>
</tr>
<tr>
<td>30–70</td>
<td>1.3</td>
<td>1.9</td>
</tr>
</tbody>
</table>

Peppard. Am J Epidemiol 2013;177(9):1006-1014
You Suspect OSA...

- Mr. Small DOES not want another diagnosis and does not think this is a big deal.

- What do you tell him?
Consequences: Excessive Daytime Sleepiness

- Increased motor vehicle crashes
- Increased work-related accidents
- Poor job performance
- Depression
- Family discord
- Decreased quality of life
Consequences: Automobile Accidents

Sassani, et al., Sleep 2004; 27:453
Consequences: Cardiovascular

- Hypertension
- Cardiac arrhythmias
- Cardiovascular disease
  - Myocardial ischemic
  - Congestive heart failure
- Cerebrovascular disease
Consequences: Mortality

Wisconsin Cohort

Busselton, Australia

Young et al. Sleep 2008; 31:1071-1078

Differential Diagnosis of Excessive Sleepiness

- Fragmented sleep
  - Insomnia
  - Sleep apnea or UARS
  - PLMD, bruxism
  - Medical conditions (pain, nocturia)
- Circadian rhythm sleep disorder
- Insufficient sleep syndrome
- Medication or substance use or withdrawal
- Narcolepsy
- Recurrent hypersomnia (Kleine-Levin)
Mr. Small Agrees to Pursue a Diagnosis…

- What diagnostic study will send Mr. Small for?
Diagnosis

- In-laboratory full night polysomnography (PSG)
  - Diagnostic Studies
  - Split night studies
- Home diagnostic systems
  - Oximetry
  - Home Sleep Tests
Polysomnogram

- Gold-Standard for Diagnosis
- EEG, EOG, Oximetry, Capnography, Leg muscle activity, Chest and abdominal effort, airflow, observations, sleep position, video monitoring, ECG
- 30 minutes set-up time
- Real-time monitoring/interactions
- Offers possible therapeutic interventions
- Usually well-tolerated and efficient
Polysomnography - Set Up
Nocturnal Oximetry

- Can indicate the oxygen desaturation index (ODI)
  - # of 4% desaturations per hours
- Look for pattern of “sawtooth abnormalities”
  - Indicates frequent saturation/desaturation events that occur with apneic/hypopneic events
Home Sleep Test

- Type 3 Device – No technician, usually at home
  - Monitors at least 4 variables –
    - 2 respiratory (flow and effort)
    - Cardiac variable
    - Oxygen saturation
Home versus Inpatient?
Advantages of Home Sleep Tests

- Convenience
  - At home in typical sleeping environment
  - Can be done at altitude

- Cost

- Better patient acceptance
Limitations of HST

- Does not determine sleep or sleep stages.
  - Averages # of events/ recording time (instead of sleep time) ➔ the AHI from HST underestimates severity of disease, leads to false negatives
  - Unable to determine REM
  - Does not assess arousals, therefore can’t diagnose RERAs
- Does not determine position
- Not validated for central disease
- Inability to diagnose and determine treatment on the same night
Patient Selection

- High Pretest probability of OSA (moderate to severe disease)
- **No comorbid conditions**
  - Pulmonary disease
  - Neuromuscular disease
  - CHF
- Do NOT use if other sleep diagnosis are suspected
- Assessment of positional therapy or OA in patients with a known h/o OSA
Study Selection:

- Mr. Small
  - Ideal for a Home Sleep Test
  - No comorbidities
    - No CHF, pulmonary disease, NM disease
  - High pretest probability
Mr. Smalls results

- AHI – 33
  - Severe sleep apnea
- Desaturation Index- 30
- Lowest desaturation – 83%
- Spent 12% of the study with an oxygen level < 90%
- Negative HST results in a patient with a high probability of OSA should proceed to an in-lab polysomnogram
But – Mr. Big, his brother

- 65 yo male
- h/o HTN, CAD, COPD with supplemental oxygen, CHF- EF 37%
- BMI 30, Mallinpotti 3, Neck 18cm

- What Type of Study would you order for him?
Mr. Big

- Needs an inpatient polysomnogram

- Comorbidities
  - CHF
    - at risk for central sleep apnea
  - COPD
    - On supplemental oxygen
    - Will need oxygen at night – but how much
Treatment Objectives

- Reduce morbidity and mortality
  - Reduce sleepiness
  - Decrease cardiovascular consequences
- Improve quality of life
Behavioral Interventions

- Encourage patients to:
  - Lose weight
  - Avoid alcohol and sedatives
  - Avoid sleep deprivation
  - Avoid supine sleep position
  - Stop smoking
Medical Interventions

- Positive airway pressure
  - Continuous positive airway pressure (CPAP)
  - Bi-level positive airway pressure
  - Auto Servo Ventilation (ASV)

- Oral appliances

- Other (limited role)
  - Medications
  - Oxygen
Positive Airway Pressure
Positive Airway Pressure
Benefits of CPAP: Mortality

Campos-Rodriguez, et al., Chest 2005; 128:624
Benefits of CPAP: Sleepiness

**CPAP Treatment**

Adapted from Lamphere J et al. Chest 1989;96.
Benefits of CPAP: Performance

Complications of CPAP

- Mask Leak
- Claustrophobia
- Skin Issues
- Dry Mouth
- Aerophagia
- Rhinitis
CPAP compliance

• Patient report: 75%

• Objectively measured use
  • 4 hrs for ≥ 5 nights / week: 46%

• Largest study of long-term adherence, 68% of patients were still using CPAP at 5 years.

CPAP Compliance: Predictors

- **Predict Good Compliance**
  - Increased AHI
  - Increased daytime sleepiness
  - Perception of benefit

- **Predict Poor Compliance**
  - Lack of EDS
  - Lack of perceived benefit
  - Nasal obstruction
  - Side effects
  - Claustrophobia

Kakkar Chest 2007;132(3):1057-72
Desensitization

1- Wear the mask alone, **while awake**, until it becomes comfortable

2- Use the mask with the CPAP machine, **while awake**, until it becomes comfortable

3- Put on the mask prior to bed & attempt to sleep with it

   It is ok if you can only tolerate it for a short period of time

   Repeat this every night
Hypnotics & CPAP Adherence

- Single center parallel designed RCT
- Eszopiclone 3mg - for 2 weeks
- Assessed at 3 and 6 months with data card downloads
- Open label sedatives allowed after 4 weeks

Lettieri. Ann Intern Med 2009 Nov 17;151(10); 696-702
Measuring Compliance

- Data Card Download
  - Measures “mask on” time
  - Residual AHI
  - Leak
- Pulse oximetry
- Objective monitoring required by CMS
# Therapy Data Summary - All Data

## Compliance Summary

<table>
<thead>
<tr>
<th>Metric</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Date Range</td>
<td>4/4/2014 - 7/2/2014 (90 days)</td>
</tr>
<tr>
<td>Days with Device Usage</td>
<td>86 days</td>
</tr>
<tr>
<td>Days without Device Usage</td>
<td>4 days</td>
</tr>
<tr>
<td>Percent Days with Device Usage</td>
<td>95.6%</td>
</tr>
<tr>
<td>Cumulative Usage</td>
<td>22 days 23 hrs. 40 mins. 3 secs.</td>
</tr>
<tr>
<td>Maximum Usage (1 Day)</td>
<td>11 hrs. 52 mins. 19 secs.</td>
</tr>
<tr>
<td>Average Usage (All Days)</td>
<td>6 hrs. 7 mins. 46 secs.</td>
</tr>
<tr>
<td>Average Usage (Days Used)</td>
<td>6 hrs. 24 mins. 53 secs.</td>
</tr>
<tr>
<td>Minimum Usage (1 Day)</td>
<td>40 mins. 34 secs.</td>
</tr>
<tr>
<td>Percent of Days with Usage &gt;= 4 Hours</td>
<td>88.9%</td>
</tr>
<tr>
<td>Percent of Days with Usage &lt; 4 Hours</td>
<td>11.1%</td>
</tr>
<tr>
<td>Total Blower Time</td>
<td>23 days 1 hrs. 32 mins. 56 secs.</td>
</tr>
</tbody>
</table>

## Auto CPAP Summary (Philips Respironics)

<table>
<thead>
<tr>
<th>Metric</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auto CPAP Mean Pressure</td>
<td>9.2 cmH2O</td>
</tr>
<tr>
<td>Auto CPAP Peak Average Pressure</td>
<td>11.1 cmH2O</td>
</tr>
<tr>
<td>Average Device Pressure &lt; 90% of Time</td>
<td>10.7 cmH2O</td>
</tr>
<tr>
<td>Average Time in Large Leak Per Day</td>
<td>29 mins. 24 secs.</td>
</tr>
<tr>
<td>Average AH1</td>
<td>3.9</td>
</tr>
</tbody>
</table>
Oral Appliances

- Indications
  - Snoring and Mild to Moderate OSA

- Efficacy
  - Variable
  - 52% of patients with AHI<10/hr on treatment

- Side effects
  - TMJ discomfort, dental misalignment, and salivation
Oral Appliance: Mechanics
Surgical Therapies

- **Reconstruct upper airway**
  - Uvulopalatopharyngoplasty (UPPP)
  - Radiofrequency tissue volume reduction
  - Genioglossal advancement
  - Nasal reconstruction
  - Tonsillectomy

- **Bypass upper airway**
  - Tracheostomy

- **Hypoglossal Nerve Stimulator**
Sites of Airway Narrowing

Adapted from Morrison DL et al. Am Rev Respir Dis 1993;148
Hypoglossal Nerve Stimulator

- Activates the genioglossus muscle via unilateral stimulation of the hypoglossal nerve.
Results

- 126 patients had stimulator implanted
  - 83% men, Mean BMI- 28, Mean age- 54.5 years
  - Mean AHI- 32, Mean ODI- 29
- Median AHI decreased 68% (29 → 9)
- Median ODI decreased 70% (25 → 7)
- 66% of cohort had AHI < 20 AND AHI decrease by 50%
- ESS, FOSQ significantly improved
Randomized withdrawal phase

- 46 patient who responded to txt randomized in 1:1
  - Cessation of stimulator or therapy maintenance
  - Repeat PSG after 1 week
Mr. Small

- AHI – 33
  - Severe sleep apnea
- Placed on an APAP
  - Range 5 → 15cm

- At Follow up
  - Feels better
  - Residual AHI 5
Medicare Considerations

This makes me want to drink!
Medicare - It is painful!

- Rules are strict

- If you are unaware of the regulations:
  - Patients may experience a delay in getting equipment
  - Patients may have to have costly, repeat testing
  - Patients may have to pay out of pocket for expensive medical equipment
  - Patients lose confidence in you
CPAP Therapy - Medicare

- Medicare pays 80%
- CPAP is rented for 13 months
  - Patients have ~$20/month copay
- Medicare will pay for a new CPAP every 5 years
  - Face-to-face visit within 6 months
- 5 things must occur for CPAP to be covered
1) Pt needs face to face visit recommending PSG

- Chart note needs:
  - signs/symptoms, duration of symptoms
  - Epworth Sleepiness Scale
  - Cardiopulmonary exam, Neck circumference, BMI

2) Sleep study must show enough apnea events:

- AHI ≥ 15 (with a minimum of 30 events)
- AHI 5-14 (with a minimum of 10 events) PLUS
  - Insomnia, Daytime sleepiness, Cognitive impairment
  - Mood Disorder, HTN, Ischemic heart disease, Hx of stroke
  - AHI of 4.9 does not count
3) **CPAP order:**
- Must include:
  - Prescriber name and signature
  - Prescriber NPI #
  - Order date

4) **After CPAP delivery, pt needs face-to-face visit between day 31-91 after starting CPAP**
- Chart notes must state that pt is benefitting from therapy and needs to continue CPAP use
5) **Pt has to show compliance with CPAP**

- 30 day consecutive period within the 1st 90 days
- Percent of days with usage ≥ 4 hours per night is at least 70% (69.5% doesn’t count)
- Clinician must document that he/she reviewed compliance data
CPAP Therapy - Medicare

- If patient fails to meet compliance criteria or does not have face to face follow-up visit, CPAP is no longer covered
  - Pt can elect to keep machine and pay out of pocket
  - Pt can give the machine back and buy a machine on their own (internet, used machine)
  - Pt can start the process over
    - Face to visit, repeat sleep study, PAP reissued
    - If starting over, patient must have in-lab test (no HST)
    - PSG may be baseline, split-night or titration
Oxygen Use with CPAP

- If patient has diagnosis of sleep apnea:
  - Must have in-lab PAP titration study showing that they still desat despite adequate treatment of sleep apnea
    - Home nocturnal oximetry no longer accepted
    - At least 2 hour titration
  - During sleep study, must show at least 5 minutes ≤ 88% while on PAP therapy
    - AHI must be <10
    - If starting AHI 5-10, AHI must be improved on PAP
  - Document possible need for O2 in chart notes referring patient for sleep study
“Some people talk in their sleep. Lecturers talk while other people sleep.”

Camus
Questions?
CHF and Central Sleep Apnea

- With ASV
  - Increased death from any Cause
    - 34.8 vs 29.3 event rate
    - HR 1.28
  - Increased death from Cardiovascular Cause
    - 29.9 vs 24 event rate
    - HR 1.34

Adaptive servo-ventilation had no significant effect on the primary end point in patients who had heart failure with reduced ejection fraction and predominantly central sleep apnea, but all-cause and cardiovascular mortality were both increased with this therapy.

Hypothesis

- CSA is good for people with CHF
- Positive airway pressure is bad for patients with CHF