Sleep Apnea and Its Impact on Cardiovascular Disease Risk

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Definition of the Disorder

- Terminology:
  - Obstructive sleep apnea (OSA)
  - Sleep apnea (SA)
  - Sleep-disordered breathing (SDB)
  - Sleep apnea-hypopnea syndrome (SAS)

Pathophysiology of Sleep Apnea

Normal
Partial Collapse
Complete Collapse

Hypopneas
Apneas

Standard Diagnostic Test: Polysomnography

- Electro-oculogram (EOG)
- Electroencephalogram (EEG)
- Electromyogram (EMG)
- Electrocardiogram (ECG)
- Airflow (nasal and oral)
- Oxyhemoglobin Saturation (SaO₂)
- Chest and Abdominal Wall Effort
- Body Position
  - (IN-LAB or IN-HOME)

Obstructive Sleep Apnea

Definition of the Disorder

Disease Defining Metric:
- Apnea-Hypopnea Index (AHI)
  - Number of apneas and hypopneas per hour of sleep
- Respiratory Disturbance Index (RDI)
- "Normal": AHI or RDI < 5 events / hour
The Sleep Heart Health Study

- **Design:**
  - Prospective cohort study
  - Multi-center
  - Assessment of sleep on ongoing cohort studies of cardiovascular and respiratory disease
  - Wide geographic and ethnic representation of middle-aged and older US adults

Cohort Eligibility

- Age ≥ 40 years
- Exclusion criteria:
  - Treatment with CPAP
  - Supplemental oxygen use
  - Tracheostomy
- Recruitment of men = women
- Minority/ethnic groups targeted

System for Home Polysomnography

- **P-series system Compumedics**
- Recorded montage
  - EEG (C3-A2, C4-A1), EOG, chin EMG, EKG
  - Oximetry, thermocouple, respiratory inductive plethysmography
  - Body position and light sensors

Outcome and Covariate Data

- **Prevalent disease**
  - Cardiovascular disease, myocardial infarction, stroke, angina, PTCA, congestive heart failure, hypertension, diabetes, asthma, and COPD

- **Demographic**
  - Age, race, education, marital status, occupation, etc.

- **Health Habits**
  - Smoking, alcohol use, caffeine, etc.

Outcome and Covariate Data

- **Anthropometrics (BMI, waist girth, hip circumferences)**
- **Medication use (prescription and non-prescription)**
- **Electrocardiogram**
- **Subset of the cohort**
  - Echocardiogram
  - Holter data
  - Head MRI scans
  - Physical activity
  - Serum (fasting, non-fasting, post glucose challenge)
  - Spirometry
**SHHS: Longitudinal Design**

Baseline PSG (N = 6441)  
Follow-up PSG (N = 3291)

- '04 '95 '96 '97 '98 '99  
- '90 '00 '01 '02 '03

Continuous Outcome Surveillance

- '04 '05 '06 '07 '08 '09 '10 '11

Outcome Surveillance  
Censoring Date: April 1, 2006  
End of Follow-up

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**Sleep apnea and Incident Hypertension**

**Prospective Study of Sleep-disordered Breathing and Hypertension**

The Sleep Heart Health Study

- George J, Gottlieb, MD, MPH; Gayane Yonesian, MD, PhD; Anurag B, Newman, MD, MPH;
- Smith J, O'Connor, MD, MSc; Narish M, Piquette, MD, PhD; Stuart F, Quinn, MD;
- Steven R, Ricker, MD; Britton E, Reaven, PhD, MPH; Elise K, Tang, MD, MA;
- Marc Danoes, West, PhD; Yool, Shaha, MD, MPH

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**Sleep Apnea: Incident CVD**

Men: Age < 70 years

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Predictor Variable</th>
<th>Hazard Ratio</th>
<th>95 % CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incident CVD</td>
<td>AHI &lt; 5 vs. AHI ≥ 30</td>
<td>1.68</td>
<td>1.02 – 2.76</td>
</tr>
<tr>
<td></td>
<td>AHI continuous</td>
<td>1.10</td>
<td>1.00 – 1.21</td>
</tr>
</tbody>
</table>

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**Sleep Apnea and Arrhythmias: SHHS**

- Sleep Apnea and Arrhythmias: SHHS

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**Epidemiology and Prevention**

**Prospective Study of Obstructive Sleep Apnea and Incident Coronary Heart Disease and Heart Failure**

The Sleep Heart Health Study

- Gurtel et al. Circulation 2010; 122: 325-338

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**Gottlieb et al. Circulation 2010; 122: 325-338**

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**Mehra et al. AJRCCM. 2006; 170: 910-916**
Sleep Apnea and Stroke in Men

<table>
<thead>
<tr>
<th>Quartile of OAHI</th>
<th>Unadjusted</th>
<th>Age-Adjusted</th>
<th>Fully-Adjusted*</th>
</tr>
</thead>
<tbody>
<tr>
<td>IV: 19.13 – 164.5</td>
<td>3.91 (1.55 – 9.86)</td>
<td>3.05 (1.21 – 7.72)</td>
<td>2.86 (1.10 – 7.39)</td>
</tr>
<tr>
<td>III: 9.50 – 19.12</td>
<td>2.35 (0.89 – 6.20)</td>
<td>1.97 (0.74 – 5.21)</td>
<td>1.86 (0.70 – 4.95)</td>
</tr>
<tr>
<td>II: 4.05 – 9.49</td>
<td>1.96 (0.71 – 5.40)</td>
<td>1.86 (0.68 – 5.13)</td>
<td>1.86 (0.67 – 5.12)</td>
</tr>
<tr>
<td>I: 0.00 – 4.04</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
</tbody>
</table>

*Adjusted for age, BMI, smoking status, SBP, blood pressure medications, diabetes, and race


Sleep Apnea and All-Cause Mortality

### Men < 70 years

<table>
<thead>
<tr>
<th>AHI (events/hr)</th>
<th>N</th>
<th>Person years</th>
<th>Deaths</th>
<th>Mortality Rate</th>
<th>Adjusted Odds Ratios (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 5.0</td>
<td>985</td>
<td>8,220</td>
<td>91</td>
<td>11.1</td>
<td>1.00</td>
</tr>
<tr>
<td>5.0 – 14.9</td>
<td>694</td>
<td>5,697</td>
<td>82</td>
<td>14.4</td>
<td>1.24 (0.90 – 1.71)</td>
</tr>
<tr>
<td>15.0 – 29.9</td>
<td>322</td>
<td>2,623</td>
<td>47</td>
<td>17.9</td>
<td>1.45 (0.98 – 2.14)</td>
</tr>
<tr>
<td>&gt; 30.0</td>
<td>168</td>
<td>1,355</td>
<td>28</td>
<td>20.7</td>
<td>2.09 (1.31 – 3.33)</td>
</tr>
</tbody>
</table>

### Men > 70 years

<table>
<thead>
<tr>
<th>AHI (events/hr)</th>
<th>N</th>
<th>Person years</th>
<th>Deaths</th>
<th>Mortality Rate</th>
<th>Adjusted Odds Ratios (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 5.0</td>
<td>277</td>
<td>2,055</td>
<td>125</td>
<td>60.8</td>
<td>1.00</td>
</tr>
<tr>
<td>5.0 – 14.9</td>
<td>282</td>
<td>2,176</td>
<td>111</td>
<td>51.0</td>
<td>0.92 (0.70 – 1.20)</td>
</tr>
<tr>
<td>15.0 – 29.9</td>
<td>140</td>
<td>1,029</td>
<td>67</td>
<td>65.1</td>
<td>1.23 (0.90 – 1.68)</td>
</tr>
<tr>
<td>&gt; 30.0</td>
<td>74</td>
<td>517</td>
<td>36</td>
<td>69.6</td>
<td>1.27 (0.86 – 1.86)</td>
</tr>
</tbody>
</table>

Normal Sleep = Cardiovascular Health