Optimizing Therapy in HF Patients with Sleep Apnea

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Case Study

- 75 year old man with long history of an LVEF of <20%
- Fatigued walking 2-3 blocks
- Very poor sleep over 2 weeks. No orthopnea or PND
- Exam: SBP=80, HR 90, Clear lungs, + JVD, + S3, No edema, BNP 2400
- Hemodynamics?
Hemodynamics

- RA 13mmHg
- RV 60/20mmHg
- PA 60/30mmHg
- PCWP 30mmHg
- CI 1.4 l/min/m²
Types of Sleep Apnea

<table>
<thead>
<tr>
<th></th>
<th>Central</th>
<th>Obstructive</th>
<th>Mixed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Respiratory flow</td>
<td><img src="image" alt="Waveform" /></td>
<td><img src="image" alt="Waveform" /></td>
<td><img src="image" alt="Waveform" /></td>
</tr>
<tr>
<td>Respiratory effort</td>
<td><img src="image" alt="Waveform" /></td>
<td><img src="image" alt="Waveform" /></td>
<td><img src="image" alt="Waveform" /></td>
</tr>
<tr>
<td>O₂ sat</td>
<td><img src="image" alt="Waveform" /></td>
<td><img src="image" alt="Waveform" /></td>
<td><img src="image" alt="Waveform" /></td>
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</tbody>
</table>
Definitions

- Apnea—Complete cessation of airflow for at least 10 seconds
- Hypopnea—Decrease in oronasal airflow by at least 50% associated with a 4% decrease in arterial saturation
- AHI—Apnea Hypopnea index. Combined episodes per hour.
- Mild: AHI 5-14, Moderate: 15-29, Severe >30
Recording date: 5/14/85
Subject's age: 64 years
Subject's gender: M

Total sleep time: 302.0 minutes
REM percentage: 10.27%

Lights Out
End of Night
Prevalence of Sleep Apnea and Heart Failure

- Sleep apnea—5-10% prevalence in the general population
- Patients with CVD-47-83% have sleep apnea
- Heart failure—2% prevalence
- 12%-53% of HF pts have OSA
- 21%-37% of HF pts have CSA
- OSA and CSA predictors of mortality in HF patients

Outcomes of Patients with HF and Sleep Apnea

• Patients with HF and OSA have a higher mortality than HF patients without OSA
• Patients with HF and CSA, cardiac mortality was higher with a higher AHI.
Clinical Diagnosis

- Symptoms of daytime somnolence, snoring, witnessed apneas, generalized poor sleep
- Questionnaires such as the Berlin Questionnaire
- Class III/IV Heart Failure
BERLIN QUESTIONNAIRE

Height (m) _______  Weight (kg) _______  Age _______  Male / Female

Please choose the correct response to each question.

CATEGORY 1

1. Do you snore?
   □ a. Yes
   □ b. No
   □ c. Don’t know

If you snore:

2. Your snoring is:
   □ a. Slightly louder than breathing
   □ b. As loud as talking
   □ c. Louder than talking
   □ d. Very loud – can be heard in adjacent rooms

3. How often do you snore
   □ a. Nearly every day
   □ b. 3-4 times a week
   □ c. 1-2 times a week
   □ d. 1-2 times a month
   □ e. Never or nearly never

4. Has your snoring ever bothered other people?
   □ a. Yes
   □ b. No
   □ c. Don’t know

5. Has anyone noticed that you quit breathing during your sleep?
   □ a. Nearly every day
   □ b. 3-4 times a week
   □ c. 1-2 times a week
   □ d. 1-2 times a month
   □ e. Never or nearly never

CATEGORY 2

6. How often do you feel tired or fatigued after your sleep?
   □ a. Nearly every day
   □ b. 3-4 times a week
   □ c. 1-2 times a week
   □ d. 1-2 times a month
   □ e. Never or nearly never

7. During your waking time, do you feel tired, fatigued or not up to par?
   □ a. Nearly every day
   □ b. 3-4 times a week
   □ c. 1-2 times a week
   □ d. 1-2 times a month
   □ e. Never or nearly never

8. Have you ever nodded off or fallen asleep while driving a vehicle?
   □ a. Yes
   □ b. No

If yes:

9. How often does this occur?
   □ a. Nearly every day
   □ b. 3-4 times a week
   □ c. 1-2 times a week
   □ d. 1-2 times a month
   □ e. Never or nearly never

CATEGORY 3

10. Do you have high blood pressure?
    □ Yes
    □ No
    □ Don’t know
## Epworth Sleepiness Scale

<table>
<thead>
<tr>
<th>SITUATION</th>
<th>CHANCE OF DOZING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sitting and reading</td>
<td></td>
</tr>
<tr>
<td>Watching TV</td>
<td></td>
</tr>
<tr>
<td>Sitting inactive in a public place (e.g., a theater or a meeting)</td>
<td></td>
</tr>
<tr>
<td>As a passenger in a car for an hour without a break</td>
<td></td>
</tr>
<tr>
<td>Lying down to rest in the afternoon when circumstances permit</td>
<td></td>
</tr>
<tr>
<td>Sitting and talking to someone</td>
<td></td>
</tr>
<tr>
<td>Sitting quietly after a lunch without alcohol</td>
<td></td>
</tr>
<tr>
<td>In a car, while stopped for a few minutes in traffic</td>
<td></td>
</tr>
</tbody>
</table>
Which HF patients should be tested?

- Nocturnal angina
- Recurrent arrhythmias
- Refractory heart failure symptoms
- Witnessed abnormal respiratory pattern or apneas
- Repetitive oxygen desaturations during sleep
What Does a Polysomnogram Entail?

8 hour overnight study

- EEG - 6 leads
- EOG (EYE) - 2 leads
- EKG - 2 leads
- Leg movement - 2 leads
- Respiratory flow - nasal/oral sensor
- $O_2$ saturation - finger pulse oximetry
- Abdomen and Thoracic strain gauges.
What are my choices when ordering a PSG?

• Diagnostic study
• Split night study
Home sleep apnea test tracing

Heart rate (BPM)

Impedance

Thermistor

SaO₂ percent

Typical tracing from a four-channel cardiopulmonary recording performed at home. The parameters measured include pulse rate, chest wall impedance, airflow, and oxygen saturation. Obstructive apneas are denoted by the letter "A."

BPM: beats per minute; SaO₂: arterial oxygen saturation.
Sleep Study Report

Body Position Statistics

<table>
<thead>
<tr>
<th>Position</th>
<th>Supine</th>
<th>Prone</th>
<th>Right</th>
<th>Left</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sleep (min)</td>
<td>150.3</td>
<td>17.0</td>
<td>114.7</td>
<td>9.0</td>
</tr>
<tr>
<td>Sleep %</td>
<td>51.7</td>
<td>5.6</td>
<td>39.4</td>
<td>3.1</td>
</tr>
<tr>
<td>pRDI</td>
<td>33.6</td>
<td>0.0</td>
<td>19.4</td>
<td>N/A</td>
</tr>
<tr>
<td>pAHI</td>
<td>28.8</td>
<td>0.0</td>
<td>10.0</td>
<td>N/A</td>
</tr>
<tr>
<td>ODI</td>
<td>18.4</td>
<td>0.0</td>
<td>5.2</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Snoring Statistics

<table>
<thead>
<tr>
<th>Snoring Level (dB)</th>
<th>&gt;40</th>
<th>&gt;50</th>
<th>&gt;60</th>
<th>&gt;70</th>
<th>&gt;80</th>
<th>&gt;Threshold (45)</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sleep (min)</td>
<td>96.5</td>
<td>21.3</td>
<td>1.5</td>
<td>0.0</td>
<td>0.0</td>
<td>39.8</td>
<td>42.2</td>
</tr>
<tr>
<td>Sleep %</td>
<td>32.8</td>
<td>7.3</td>
<td>0.5</td>
<td>0.0</td>
<td>0.0</td>
<td>13.7</td>
<td></td>
</tr>
</tbody>
</table>

Sleep Stages Chart

- Wake: 27.6%
- Lights Out: 72.2%
- Total: 100.0%

Sleep Latency: 56 min
REM Latency: 83 min
Number of Wakes: 12

Respiratory Indices Chart

- pRDI: 25.82
- pAHI: 18.89
- ODI: 11.57

*Reference values are according to AASM guidelines.*
Apnea link

- O2 sat
- Resp effort
- Nasal flow
- Pulse
- Snoring
Home versus sleep lab: These tests are more for OSA: Don’t use for the following

- Moderate to severe COPD
- Neuromuscular disease
- Recent stroke
- Severe insomnia
- Class III or IV CHF
- Seizures
- BMI > 45
- Less common sleep disorders: Narcolepsy, parasomnias, periodic limb movements, CSA
## Advantages and disadvantages of home sleep apnea testing for obstructive sleep apnea

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased accessibility</td>
<td>Absence of a trained technologist to correct and clarify artifacts, make ongoing equipment adjustments, or intervene in medically unstable patients</td>
</tr>
<tr>
<td>Patient acceptance</td>
<td>Potential data loss or distortion; higher technical failure rate than polysomnography</td>
</tr>
<tr>
<td>May be done in the home</td>
<td>Potential for misinterpretation of the results due to limited data</td>
</tr>
<tr>
<td>Convenience</td>
<td>Inability to perform subsequent multiple sleep latency testing according to standard protocol</td>
</tr>
<tr>
<td>Decreased labor costs</td>
<td>Varied sensor technology</td>
</tr>
<tr>
<td>Can be done for more than one night</td>
<td>Most devices have no measurement of sleep</td>
</tr>
</tbody>
</table>

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Obstructive Sleep Apnea Can Cause Heart Failure

- Increased afterload due to negative intrathoracic pressure
- Hypoxia
- Increased sympathetic tone
- Increased catecholamines
- Vascular endothelial dysfunction
• In a randomized trial, over 2700 patients with obstructive sleep apnea and cardiovascular disease were assigned to CPAP plus usual care or to usual care alone.

• At a mean of 3.7 years, the rate of adverse cardiovascular events did not differ significantly between the groups.
Cumulative Event Curve of the Primary End Point.


No. at Risk

<table>
<thead>
<tr>
<th></th>
<th>CPAP</th>
<th>Usual care</th>
</tr>
</thead>
<tbody>
<tr>
<td>1346</td>
<td>1222</td>
<td>1118</td>
</tr>
<tr>
<td>754</td>
<td>482</td>
<td>278</td>
</tr>
<tr>
<td>146</td>
<td>146</td>
<td>146</td>
</tr>
<tr>
<td>1341</td>
<td>1211</td>
<td>1108</td>
</tr>
<tr>
<td>727</td>
<td>499</td>
<td>290</td>
</tr>
<tr>
<td>103</td>
<td>103</td>
<td></td>
</tr>
</tbody>
</table>

Follow-up (mo)

P = 0.34
Can Central Sleep Apnea Exacerbate Heart Failure?

- Hypoxia
- Increased sympathetic tone
- Increases in heart rate
- Increases in blood pressure
- Arrhythmias
How CHF May Induce Central Sleep Apnea

• Elevated PCWP causes hyperventilation through pulmonary vagal irritant receptors
• $\text{CO}_2$ decreases
• Triggers apneas
CHF May Lead to OSA

• Increased filling pressures can result in pharyngeal edema, which can reduce cross-sectional area in the airway
Positional Therapy
Klimaszewski et al Chest Mar;115(3):771-81

• Good Candidates
  – lower BMI
  – younger
  – better sleep consolidation
  – lower AHI
  – less desaturation

• Success equal to nCPAP
CSA: Treatment

- Treat the heart failure
- Pharmacologic therapy
- CPAP/BiPAP/adaptive servoventilation
- Oxygen
- Pacing (?)
- CO₂ (?)
Oxygen

• Can reduce AHI by 50%
• Decreases urine norepinephrine
• No effect on daytime plasma norepinephrine
• No effect on quality of life
• No effect on daytime sleepiness
• Does not predictably improve cardiac function
CPAP versus $O_2$

- Both decreased AHI by 67%
- CPAP improved ventilatory efficiency and LVEF; $O_2$ did not
Positive Airway Pressure: Treatment Modalities

- **Continuous positive airway pressure (CPAP):** remains continuous throughout the night; prevents airway obstruction
- **Bilevel positive airway pressure (BiPAP):** separate inspiratory and expiratory pressure; may improve tolerance
- **Adaptive servoventilation (ASV):** reacts to breathing patterns to cause a more stable respiratory pattern
CANPAP Results

- In patients with HF and sleep apnea, at 2 years there was no difference in survival without transplantation between those receiving and not receiving CPAP.
- There were beneficial finding such as a decrease in the AHI and improvements in EF and neurohormones.
- The clinical rate of events overall was less than expected leading to early cessation of the trial.

CANPAP Revisited

• Post-hoc evaluation of patients who had early suppression of CSA (at 3 months)
• Two groups: CPAP suppressed group to AHI < 15 and non-suppressed group
• EF and transplant-free survival were improved in the group in which CPAP suppressed the AHI

CPAP uptitration

- With CSA, uptitration needs to be slow
- Start with 5cm H2O for 4-6 weeks
- Restudy with uptitration as tolerated
Improvements in AHI With Different Treatments

- Oxygen: AHI: declined from 44.5 ± 3.4/h (SEM) untreated to 28.2 ± 3.4/h
- CPAP: 26.8 ± 4.6/h
- BiPAP: 14.8 ± 2.3/h
- ASV: 6.3 ± 0.9/h
Effects of adaptive servo-ventilation
SERVE-HF Trial

- Large randomized clinical trial in pts with adaptive servo ventilation
- Did not reduce combined endpoint of all cause death, transplantation, VAD implant, sudden cardiac arrest, or HF hospitalization
- Increase in CV mortality with ASV
- ? Related to positive pressure and inaccuracy of pressure delivery
SERVE-HF trial

Higher death from CV Disease with ASV
Atrial Overdrive Pacing

- In patients with bradycardia, atrial overdrive pacing can decrease apneas and hypopneas.
- These results have not been reproduced despite several attempts.

Biventricular Pacing

• Evidence to support improvement in OSA with biventricular pacing if indicated for HF
• Evidence for a decrease in circulation time
• Improvements in CSA/CSR with biventricular pacing
• These findings support the role of BiV pacing in both CSA and OSA
Treatment Issues-Tolerability
How to make CPAP work

• Heated Humidity
• Mask choices
• Follow-up call (especially in first week)
Phrenic Nerve Stimulation

- Respocardia
- Nerve stimulator placed in pectoral region
- Paces diaphragm during sleep by stimulating phrenic nerve
- Left pericardiophrenic vein or right brachiocephalic vein
- Sensing lead in azygos vein
This is a brief overview of information related to FDA's approval to market this product. See the links below to the Summary of Safety and Effectiveness Data (SSED) and product labelling for more complete information on this product, its indications for use, and the basis for FDA’s approval.
Two strategies to treat central sleep apnoea in heart failure.
Figure 1: Elimination of respiratory instability and improvement in oxygenation during unilateral phrenic nerve stimulation in a heart failure patient with central sleep apnoea.
### Table 3  Categorical change in the severity of sleep apnoea based on the apnoea-hypopnoea index

<table>
<thead>
<tr>
<th>Severity/AHI (events/h)</th>
<th>Control night* (<em>n = 16</em>)</th>
<th>Therapy night* (<em>n = 16</em>)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild (&lt;15)</td>
<td>0</td>
<td>5 (31.3%)</td>
</tr>
<tr>
<td>Moderate (15–30)</td>
<td>1 (6.3%)</td>
<td>8 (50.0%)</td>
</tr>
<tr>
<td>Severe (&gt;30)</td>
<td>15 (93.8%)</td>
<td>3 (18.8%)</td>
</tr>
</tbody>
</table>

AHI, apnoea–hypopnoea index.

*Wilcoxon's matched pairs signed-rank test, P = 0.001.*
Remede system clinical trial

- 151 patients randomized
- 51% had a greater than 50% decrease in AHI in treatment versus 11% in control
- 9% cases of adverse effects in control group, 8% in treatment group
- In HF group (64%), 63% vs. 4% had decrease in AHI by greater than 50%

Costanzo et al. Lancet 388.10048:974-982
Decreased Percentage of AHIs with Phrenic Nerve Stimulation
Conclusion

• Use a low threshold when looking for sleep apnea in heart failure patients
• Both sleep apnea and heart failure can exert adverse effects on each other
• Aggressive intervention in the realms of both heart failure and sleep apnea is critical
• More study is required to identify best treatment patterns