Obesity Hypoventilation Syndrome and Obstructive Sleep Apnea

Authors
Aesha M. Jobanputra, MD
Joyce Epelboim, MD
Richard Schwab, MD
Ilene Rosen, MD

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Stacey Kassutto, MD, MA

Section Editors
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William Merwin, MD
Michael Ray, MD

2022 Bhavin Dalal, MBBS, MD
Janaki Deepak, MBBS, FACP

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Educational Objectives:
1. Review the key difference in examination, laboratory values, and diagnostic testing between obesity hypoventilation syndrome (OHS) and obstructive sleep apnea (OSA)
2. Understand the different treatment options for OHS and OSA
3. Review different non-invasive ventilation techniques available

Scenario 1:
A 51-year-old morbidly obese man with mild persistent asthma presents for a yearly visit in the pulmonary clinic. He denies any recent wheezing, cough, or shortness of breath, but complains of fatigue that has been slowly worsening over the past year. He is embarrassed because he recently fell asleep during an important meeting at work. His wife made the trip with him today because she is concerned about him “zoning out” while driving.

Question 1: What are the potential causes of the patient’s sleepiness? What additional history should be obtained?

Sleep disordered breathing (SDB) refers to abnormalities of breathing during sleep including obstructive sleep apnea (OSA), central sleep apnea (CSA), obesity hypoventilation syndrome (OHS), and sleep related hypoventilation. This discussion will focus on OSA and OHS as they are commonly evaluated and managed in the pulmonary clinic.
Table 1. Patient history features of SDB that can guide clinical evaluation.

<table>
<thead>
<tr>
<th>Patient History</th>
<th>Guidance</th>
</tr>
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<tbody>
<tr>
<td># Snoring&lt;br&gt;# Nocturnal awakening due to gasping/choking</td>
<td><strong># Sleep Apnea:</strong> Obstructive sleep apnea can lead to poor quality of sleep. It is important to ask about snoring, nocturnal choking/gasping for air, witnessed apneas (if there is bed partner), and non-restorative sleep. Snoring is the most common symptom of OSA and occurs in 70-95% of patients with OSA.¹,²&lt;br&gt;# Suspicion of OSA can be calculated from simple tool like STOP-BANG or DoISnore50 (See below)*</td>
</tr>
<tr>
<td># Sleep schedule and naps (bedtime, wakeup time, number of times waking after sleep, sleep latency)&lt;br&gt;# Insomnia</td>
<td><strong># Total sleep time:</strong> Insufficient sleep contributes to sleepiness. Sleep plays a key role in optimal health. The consensus recommendation from the American Academy of Sleep Medicine (AASM) and Sleep Research Society (SRS) recommend 7 or more hour of sleep per night on regular bases for adults.³&lt;br&gt;<strong># Sleep Fragmentation:</strong> If a patient does sleep for 8-9 hours per night but is woken up frequently, he/she may not be getting adequate N3 or REM sleep. Additionally, asking what wakes him/her up (i.e., wheezing, need to urinate, chest pain, heart burn, cough from post-nasal drip, coughing/gasping for air, etc.) can help you identify other diagnoses that may be the primary problem.&lt;br&gt;<strong># Insomnia in the absence of coughing/gasping frequently leads to sleep apnea diagnosis and may be present in 50% of patients with sleep disordered breathing.⁴</strong></td>
</tr>
<tr>
<td># Screen time (phone, TV, tablets etc.) prior to sleep and during sleep time</td>
<td>Excessive screen time may be correlated with insomnia and poor-quality sleep.</td>
</tr>
<tr>
<td># Leg pain/movements</td>
<td><strong># Restless Legs Syndrome (RLS):</strong> Does the patient have trouble falling asleep due to uncomfortable sensation or pain in his/her legs that usually occurs at night and is relieved with movement? The criteria required for identification of RLS are: (1) an urge to move the legs often accompanied by unpleasant sensations; (2) the urge is worsened during rest or inactivity; (3) the urge is improved with leg movement; and (4) the urge is worsened in the evening or night.⁵&lt;br&gt;<strong># Sleep apnea patients may also have leg movement but no specific urge to move the legs which is instead called periodic limb movement of sleep (PLMS).</strong></td>
</tr>
<tr>
<td># Morning headache</td>
<td># May happen due to unrefreshed sleep, but excessive headache may point towards obesity hypoventilation syndrome (OHS).</td>
</tr>
<tr>
<td># Sleep paralysis, Cataplexy, hypnogogic hallucinations</td>
<td><strong># Narcolepsy:</strong> Weakness during periods of strong emotions is known as cataplexy which is almost pathognomonic symptoms for narcolepsy although every narcolepsy patient does not have cataplexy.</td>
</tr>
<tr>
<td># Excessive daytime sleepiness/Tiredness/unrefreshed sleep</td>
<td># A number of conditions can cause excessive daytime sleepiness (EDS) including OSA, sleep fragmentation, insufficient sleep (most common for young people including residents and fellows), medication usage, hypersomnia disorders, and narcolepsy.&lt;br&gt;**# Severity of EDS can be evaluated by a tool like Epworth Sleepiness Scale (ESS), (See below). **</td>
</tr>
</tbody>
</table>

*The mnemonic for STOP-BANG⁶: One point is given for each feature, if present.
S – Snoring Loudly (loud enough to be heard through a closed door)
T – Tiredness
O – Observed Apnea
P – Pressure (HTN)
B – BMI > 35 kg/m²
A – Age > 50 years
N – Neck circumference (>16 inch/40 cm)
G – Gender (male)
At scores from 0 to 2 the probability of moderate to severe OSA is 18%. At scores from 7 to 8 the probability of moderate to severe OSA is 60%. The sensitivity of STOP-Bang $\geq 3$ for moderate OSA is 93% and 100% for severe OSA. **In general, a score < 3 predicts low-likelihood of OSA and score $\geq 3$ predicts high-likelihood of OSA.**

While the STOP-BANG is commonly used, DOISNORE50 has been found to perform better compared to the STOP-BANG and has been validated to identify post operative patients who may develop respiratory or neurological issues after surgery.\(^7\)

*DoISnore50 includes these risk factors, one points for each of the following:
- D – Diseases (Stroke/afib/hypertension)
- O – Observed apnea
- I – Insomnia
- S – Snoring
- N – Neck circumference over 18 inches
- O – Obesity
- R – Are you male
- E – Excessive daytime sleepiness

50 – Age $\geq 50$

**A cutoff of $> 6$ was associated with a sensitivity of 58% and 81% specificity for OSA.**

**Subjective Severity of Sleepiness:** The amount of sleepiness can be reported by patients using the Epworth Sleepiness Scale (image to below).\(^8\) It can be useful to quantify the degree of daytime sleepiness and monitor response to treatment. The score ranges from 0 to 24, with scores $>10$ consistent with pathologic sleepiness.

\[
\text{The Epworth Sleepiness Scale}
\]

<table>
<thead>
<tr>
<th>Situation</th>
<th>Chance of dozing</th>
</tr>
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<tbody>
<tr>
<td>Sitting and reading</td>
<td></td>
</tr>
<tr>
<td>Watching TV</td>
<td></td>
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<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>
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<tr>
<td>In a car, while stopped for a few minutes in the traffic</td>
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</table>

Figure 1. Epworth Sleepiness Scale Questionnaire.
In addition to the risk factors discussed above, OSA is associated with:

- **Age:** Prevalence of OSA increases from adulthood through 6-7th decade of life
- **Male sex:** It is 2-3x more common in men than women. This gender gap does narrow after menopause in women
- **Obesity:** 10% increase in weight has shown to be associated with 6-fold increase in incidence of OSA. In a population-based study, prevalence of moderate to severe OSA was demonstrated to be 63% with BMI > 30 kg/m²
- **Craniofacial and upper airway abnormalities**
- **Nasal congestion in adults** doubles the risk for OSA compared to controls

**Scenario 1 (cont.):**

This **51-year-old male** complains of sleepiness for at least a year. It is worst when he is sedentary, and he often falls asleep while reading or watching television. Recently, he has **fallen asleep several times at his job** as a software engineer, including during an important meeting. On days when he is especially tired, he uses his lunch break to take a quick nap in his car before returning to work. He has **difficulty staying awake while driving longer distances**, and recently, he dozed off momentarily and hit the rumble strips on the side of the highway. He usually gets into bed at 10:30 PM (though he often falls asleep earlier while watching TV) and falls asleep “instantly.” He occasionally awakens feeling as if he is choking or suffocating. This sensation goes away quickly once he is awake. **He wakes up 3-4x per night to urinate.** He does not notice nocturnal wheezing and does not have nocturnal leg cramps. He wakes up in the morning at 6:30 AM using the alarm clock, but often hits the snooze until around 7 AM. He usually **feels in the morning as if he “barely slept.”** He often has a **dry mouth** when he awakens. His wife notes that he **snorers loudly.** Because of his snoring, she sometimes moves to the guest bedroom to sleep. On the weekends, he sleeps until 8:30 AM or 9 AM and tries not to nap but often finds himself dozing off for up to an hour if he is not keeping active. No matter how long he sleeps, he rarely feels rested. **His Epworth Sleepiness Score is 13.**

**Exam shows:**

- **BP 145/85, HR 75, RR 18, Weight 345 lbs., Height 5’10”**
- **General:** Morbidly obese middle-aged man, face somewhat flushed, in no distress
- **Neck circumference 19 inches, BMI 49.5 kg/m²**
- **HEENT:** PERRL, injected conjunctiva, large uvula, narrowing of the peritonsillar lateral walls and tongue ridging
- **Lungs:** breath sounds clear to auscultation throughout, no rales, rhonchi, or wheezes
- **Cards:** heart sounds regular, no murmurs, gallops, rubs
- **Abdomen:** soft, non-tender, obese, bowel sounds present
- **Extremities:** no clubbing or cyanosis, trace pedal edema
- **Neuro:** non-focal exam, DTRs intact

**Question 2:** What is the most likely diagnosis for his sleepiness? What are his risk factors for each?

Among causes of SDB, the patient likely has OSA. He gets approximately 8 hours of sleep on the weekdays and 10 hours of sleep on the weekends. The quantity of sleep is sufficient. He denies symptoms related to restless legs syndrome. Additionally, he does not have any REM-
disturbance symptoms such as hypnagogic hallucination or sleep paralysis. Narcolepsy, though sometimes presents in ages 40-50, is less likely – especially in this patient given other symptoms.

Obesity hypoventilation syndrome, however, cannot be ruled out based on the information available.

This patient’s risk factors for OSA include increased age, male gender, and obesity.

Symptoms that suggest OSA are: loud snoring, nocturnal choking/gasping for air, nocturnal polyuria (increased release of atrial natriuretic peptide (ANP) secondary to increased negative intrathoracic pressure due to inspiratory effort against a closed airway and in turn increased venous return), dry mouth, non-restorative sleep, excessive daytime sleepiness.

Signs that suggest OSA are obesity, large neck, crowded upper airway, hypertension.

This patient’s STOP BANG Score = 7 and DOISNOWRE50 = 7.

**Question 3: What types of tests can be used to confirm a diagnosis of sleep apnea?**

There are three different types of sleep studies that could be ordered for this patient:

1. **Diagnostic polysomnography (PSG):** reports electroencephalogram (EEG), electrooculogram (EOG), electromyogram (EMG) for chin and legs, airflow signals, respiratory effort signals for chest and abdomen, oxygen saturation, body position, and electrocardiogram (ECG).

   PSG can be used to diagnose OSA, central sleep apnea (CSA), sleep-related hypoventilation disorders, REM behavior disorder, parasomnias, narcolepsy, and hypersomnia (in which case PSG would be followed by Multiple Sleep Latency Test), periodic limb movement disorder, bruxism, etc.

2. **Split-night study:** reports the same parameters as the diagnostic PSG, however, the study is split into first diagnostic half and then a second treatment part can be initiated the same night. To qualify for PAP titration during the second half of the night at least moderate OSA must be seen during at least 2 hours of sleep time and 3 hours must remain left in the night for PAP titration. Split night studies have appropriate sensitivity to diagnose OSA and may provide enhanced efficiency of care by diagnosing and establishing PAP treatment needs within a single night. Examples of risk factors for nondiagnostic studies include severe insomnia, claustrophobia, concern for non-breathing related sleep disorders, or concern for non OSA types of SDB.14

3. **Unattended, home sleep apnea test (HSAT):** reports airflow signals, respiratory effort signals (single or dual), oxygen saturation, ECG, sleep/wake or monitoring time, and snoring. Per the American Academy of Sleep Medicine, HSAT is indicated to diagnose only OSA in uncomplicated adults presenting with signs and symptoms that indicate an increased risk of moderate to severe OSA.15 It is important to note the relative contraindications of HSAT like central sleep apnea, HFrEF, severe pulmonary disease like COPD or ILD, patients on home oxygen, recent stroke etc.
In our patient, HSAT is a good choice as he has high likelihood of OSA and absence of comorbid factors listed above. Importantly, if a HSAT is negative or inconclusive but suspicion for SDB remains, diagnostic polysomnogram should be performed.

**Scenario 1 (cont.):**

The patient underwent a sleep study that demonstrated the following: his latency to sleep onset was <2 minutes; his sleep efficiency was 89%. He had fragmented sleep with 61 arousals/hour. His Apnea-Hypopnea Index (AHI) was 90 events/hour. There were no periodic limb movements.

His tracing is shown below:

![Sleep Study Tracing](image)

**Question 4: What do the tracings demonstrate?**

This type of tracing is known as a Hypnogram. The top panel shows different stages of sleep. Note that this patient never attains N3 or REM sleep. He also has multiple awakenings. The middle panel demonstrates that patient has multiple obstructive sleep apneas and hypopneas as soon as he falls asleep. The bottom panels show desaturation events throughout the study. During obstructive apneas and hypopneas, individuals have collapse of the upper airway, which leads to oxyhemoglobin desaturation and/or arousal from sleep. Thus, accompanying the many sleep-disordered breathing events observed in this patient (apnea graph), cyclical desaturations are recorded by the SaO2 graph. He has severe OSA based on AHI of 90/hour with predominantly obstructive apneas and hypopneas.

<table>
<thead>
<tr>
<th>No OSA</th>
<th>Mild OSA</th>
<th>Moderate OSA</th>
<th>Severe OSA</th>
</tr>
</thead>
<tbody>
<tr>
<td>AHI &lt;5</td>
<td>AHI 5 to 15</td>
<td>AHI 15 to 30</td>
<td>AHI &gt; 30</td>
</tr>
</tbody>
</table>

*Figure 2. Obstructive sleep apnea severity ratings in adults.*
Question 5: What options exist for treating OSA?

Treatment options include:

1. **Continuous positive airway pressure (CPAP):** first line, most effective therapy, but not tolerated by all patients. CPAP increases the intraluminal pressure so that it is greater than the pharyngeal transmural pressure, keeping the airway open. A recent meta-analysis with 35 randomized control trials shows that CPAP was more effective compared to sham in reducing AHI and improving sleepiness based on ESS.

2. **Behavior modification:**
   a. Weight loss – weight loss and exercise should be recommended for all overweight patients with OSA. Weight loss rarely cures OSA unless there is significant amount of weight loss, i.e., from a bariatric procedure. Weight loss does reduce AHI.
   b. Positional therapy – if patient is found to have strong positional component, i.e., much higher AHI in supine position, sleeping in non-supine position can improve AHI. Several over the counter devices exist such as Zzoma pillows.
   c. Alcohol avoidance – alcohol can exacerbate OSA symptoms, cause sleep fragmentation, and can depress the respiratory system.
   d. Sedative avoidance – any of the sedatives with respiratory depressant properties can also exacerbate the OSA symptoms.

3. **Oral appliance:** this is often used as second line therapy in patients with moderate to severe OSA who cannot tolerate PAP therapy. It can be used as first line therapy in patients with mild OSA and no other comorbidities. AASM recommends repeating the sleep study once the patient is fit with an oral mandibular device.

4. **Upper airway surgery:** It is difficult to predict which patient would benefit from an upper airway surgery. Tonsillectomy and adenoidectomy are the mainstay of therapy in non-obese children with OSA, but these are rarely effective treatment in adults.

5. **Hypoglossal Nerve Stimulation:** Also used as second line therapy for OSA. Patients will often need drug-induced sleep endoscopy to determine the pattern of airway collapse. This modality can be used in patients with OSA who have ineffective pharyngeal dilator muscles.

6. **Supplemental oxygen:** can improve oxygen saturation but may prolong apneas and does not decrease the number of events; therefore, in general, oxygen alone is not considered to be effective therapy.
Question 6: What does the tracing below demonstrate?

The tracing is from a split night study. CPAP titration begins just before 2 AM. Initially, the patient still has lots of events. However, during the REM sleep period, CPAP increased to 13 cm H2O, at which pressure nearly all breathing events are abolished. However, his oxygen saturation remains close to 90% and often below that (15% of the night with saturation <88%). So, at CPAP of 15 cm H2O where his apneas are eliminated, he remains hypoxic.

During the second half of the sleep study, he is treated with continuous positive airway pressure. When he is titrated to a pressure of 13 cm H2O, his apnea-hypopnea index is reduced to 5 events/hour. At this setting, his arousal index decreases to 2 events/hour and his sleep is much more consolidated. He awakens feeling refreshed early the next morning (“better than I’ve slept in years”).

However, in reviewing his study, you notice that although his AHI appears to have been normalized by CPAP, his oxyhemoglobin saturations remain low (15% of time at 13 cm H2O, patient still had oxyhemoglobin saturations between 80-90%).

Question 7: What is the most likely explanation for this patient’s persistent hypoxemia?

He likely has OHS. OHS is defined by BMI > 30 kg/m², a resting PaCO₂ of more than 45 mmHg, and absence of an alternative cause of alveolar hypoventilation. It is often associated with worsened nocturnal hypercapnia, nocturnal hypoxemia, and OSA.18-21

OHS is a diagnosis of exclusion and other conditions commonly associated with hypercapnia should be ruled out. In 90% of patients with OHS, the sleep-disordered breathing is obstructive sleep apnea. The other 10% may have sleep-related hypoventilation (an...
increase in PaCO\(_2\) of > 10 mm Hg above that of wakefulness or significant oxygen desaturations) that is not the result of obstructive apneas or hypopneas.

**Question 8: What diagnostic tests can be used to confirm OHS?**

You can check an arterial blood gas, which would likely show a chronic respiratory acidosis, with elevated PCO\(_2\) and borderline PaO\(_2\). You can also check serum chemistry, which would likely show an elevated HCO\(_3\). Early diagnosis of OHS can improve outcomes and one such way to work up an OHS patient is mentioned below.\(^{22}\)

**Figure 5. Evaluation algorithm for OHS.**

**Question 9: What treatment options exist for OHS?**

In a prospective trial, 57% of ambulatory patients with severe OHS can be successfully treated with CPAP alone while the remaining 43% of patients failed CPAP titration due to persistent hypoxemia at therapeutic pressure.\(^{23}\) Bilevel PAP (BPAP) should be instituted if the patient is intolerant of higher CPAP pressures (>15 cmH\(_2\)O) that are required to resolve apneas and hypopneas or if the hypoxemia persists despite elimination of apneas and hypopneas with adequate CPAP pressures. During BPAP titration, IPAP should be 8-10 cmH\(_2\)O above EPAP to increase ventilation. BPAP S/T can also be used. BPAP S/T allows us to add back up rate to bilevel positive airway pressure to help maintain ventilation. Adherence to PAP therapy has shown to improve PaCO\(_2\), PaO\(_2\), and decrease the need for oxygen therapy.\(^{24-26}\) See figures below.\(^{23}\)
**Figure 6. Suggested therapeutic algorithm during CPAP titration in patients with OHS. Borrowed from Mokhlesi B. Respir Care 2010.**

Common Modes of PAP Therapy

<table>
<thead>
<tr>
<th></th>
<th>CPAP</th>
<th>APAP</th>
<th>BPAP</th>
<th>ASV</th>
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<tbody>
<tr>
<td><strong>Definition</strong></td>
<td>Continuous positive airway pressure; uses single pressure above ambient pressure.</td>
<td>Like CPAP but pressure adapts to eliminate OSA</td>
<td>Bilevel positive airway pressure; IPAP which is during inhalation and EPAP during exhalation.</td>
<td>Adaptive servo ventilation; provides variable amounts of pressures that alternate between and during inhalation and exhalation.</td>
</tr>
<tr>
<td><strong>Prescription</strong></td>
<td>CPAP</td>
<td>PAP range</td>
<td>IPAP/EPAP (back up respiratory rate if S/T)</td>
<td>EPAP, PS (min and max), back up rate</td>
</tr>
<tr>
<td><strong>Indications</strong></td>
<td>OSA, OHS</td>
<td>OSA</td>
<td>OSA, hypoventilation, neuromuscular diseases, Pulmonary edema, COPD exacerbation</td>
<td>Hypoventilation, CSA in patients with preserved EF, complex apnea</td>
</tr>
</tbody>
</table>

**References:**


