Obesity Related Hypoventilation Syndrome and Sleep Apnea

Kendal Mitchell, D.O.
Sleep Disordered Breathing

- Abnormality in the frequency, pattern, upper airway resistance and/or depth of breathing during sleep
- Affects 2-9% of middle aged adults, 15% of older adults
- Types:
  - Obstructive sleep apnea/hypopnea syndrome
  - Obesity hypoventilation syndrome
  - Central sleep apnea
  - Cheyenne-Stokes respiration
  - Upper airway resistance syndrome

Objectives

- Review obesity hypoventilation syndrome
- Define obstructive sleep apnea
- Review risk factors and associated comorbidities
- Diagnostic testing and therapy
Obesity Hypoventilation Syndrome

- Obesity
  - BMI >30kg/m²
- Awake arterial hypercapnia
  - $\text{PaCO}_2 > 45\text{mmHg}$
- Evidence of sleep disordered breathing
- Absence of other causes of hypoventilation/hypercapnia
Obesity Hypoventilation Syndrome

- Prevalence estimated to be 10-20% in obese patients with OSA
- OSA accounts for 90% of the sleep disordered breathing in OHS
- Remaining 10% have sleep hypoventilation
  - $\text{PaCO}_2 > 10\text{mmHg}$ above that of wakefulness or
  - Significant oxygen desaturations
  - Neither a result of obstructive apneas or hypopneas
Obstructive sleep apnea

- A disorder in which complete or partial obstruction of the airway during sleep causes:
  - Loud snoring
  - Oxyhemoglobin desaturations
  - Frequent arousals

- As a result, affected persons have unrestful sleep and excessive daytime sleepiness

Epidemiology of OSA

- Currently seen in 2% of middle-aged women and 4% of middle-aged men

- Incidence is increasing due to:
  - Relationship to obesity
  - Increased public awareness resulting in more patients and family members bringing symptoms to the attention of health care providers

Risk Factors

- **Known risk factors:**
  - Obesity - prevalence of OSA progressively increases as the body mass index and associated markers increase
    - neck circumference, waist-to-hip ratio
  - Craniofacial abnormalities - abnormal maxillary or short mandibular size, wide craniofacial base
  - Upper airway soft tissue abnormalities - tonsillar hypertrophy, adenoid hypertrophy

- **Potential risk factors:**
  - Heredity
  - Smoking - smokers (but not past smokers) 3x more likely to have OSA than never smokers
  - Nasal congestion - two-fold increase in the prevalence of OSA

Recognition of Obstructive Sleep Apnea

- Often begins in the primary care office
  - Routine health maintenance evaluation
  - Evaluation of symptoms of OSA
  - Part of comprehensive evaluation of patients at high risk for OSA
Common Complaints

- Loud snoring
- Hypersomnolence
- Depressed mentation
- Altered personality
- Impotence
- Headaches upon waking
- Nocturia
OSA Screen: Questions for Routine Health Maintenance

- Does the patient snore?
- Does the patient complain of excessive daytime sleepiness?
Epworth Sleepiness Scale

- Sitting and reading
- Watching television
- Sitting inactively in a public place
- Riding as a passenger in a car for one hour without a break
- Lying down to rest in the afternoon when circumstances permit
- Sitting and talking with someone
- Sitting quietly after lunch without alcohol
- Sitting in a car as the driver, while stopped for a few minutes in traffic

Score $>10 = \text{excessive sleepiness}$
Questions for Routine Health Maintenance

- Does the patient snore?
- Does the patient complain of excessive daytime sleepiness?
- Does the patient have hypertension?
- Is the patient retrognathic?
- Is the patient obese?

Positive findings indicate need for comprehensive sleep history and physical examination
**STOP-Bang Sleep Apnea Questionnaire**

<table>
<thead>
<tr>
<th>STOP</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Do you SNORE loudly (louder than talking or loud enough to be heard through closed doors)?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Do you often feel TIRED, fatigued, or sleepy during daytime?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Has anyone OBSERVED you stop breathing during your sleep?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Do you have or are you being treated for high blood PRESSURE?</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>BANG</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>BMI more than 35kg/m²?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>AGE over 50 years old?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>NECK circumference &gt; 15.75 inches (40cm)?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Male GENDER?</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

Score < 3 low probability of OSA
Score > 3 high probability of OSA
High STOP-Bang score indicates a high probability of obstructive sleep apnea

- Evaluated the association between STOP-Bang scores and the probability of OSA
- 746 preop patients completed STOP-Bang and then in-lab or portable PSG

High STOP-Bang score indicates a high probability of obstructive sleep apnea

- In the surgical population, a STOP-Bang score of 5–8 identified patients with high probability of moderate/severe OSA

- The STOP-Bang score can help stratify patients for unrecognized OSA

Berlin Questionnaire

- Developed in 1996 at the Conference on Sleep in Primary Care in Berlin, Germany

- 10-question test
  - Three categories including:
    - Snoring severity
    - Excessive daytime sleepiness
    - History of high blood pressure or obesity

- Scores positive in at least 2 of the 3 categories = high risk for obstructive sleep apnea
**Berlin Questionnaire**

Sleep Evaluation in Primary Care

Please Complete the following:

height __________  age __________

weight __________  male/female __________

1. Do you snore?
   - □ yes
   - □ no
   - □ don’t know

If you snore:

2. Your snoring is?
   - □ slightly louder than breathing
   - □ as loud as talking
   - □ louder than talking
   - □ very loud. Can be heard in adjacent rooms.

3. How often do you snore?
   - □ nearly every day
   - □ 3-4 times a week
   - □ 1-2 times a week
   - □ 1-2 times a month
   - □ never or nearly never

4. Has your snoring ever bothered other people?
   - □ yes
   - □ no

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

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

7. During your waketime, do you feel tired, fatigued or not up to par?
   - □ nearly every day
   - □ 3-4 times a week
   - □ 1-2 times a week
   - □ 1-2 times a month
   - □ never or nearly never

8. Have you ever nodded off or fallen asleep while driving a vehicle?
   - □ yes
   - □ no

   if yes, how often does it occur?
   - □ nearly every day
   - □ 3-4 times a week
   - □ 1-2 times a week
   - □ 1-2 times a month
   - □ never or nearly never

9. Do you have high blood pressure?
   - □ yes
   - □ no

10. BMI > 30 (See Chart)

Scoring Questions: Any answer within box outline is a positive response.

Scoring categories:
- □ Category 1 is positive with 2 or more positive responses to questions 1-5
- □ Category 2 is positive with 2 or more positive responses to questions 6-8
- □ Category 3 is positive with 1 positive responses to questions 9-10

Final Result: If 2 or more possible categories are positive, you have a high likelihood of sleep apnea.

| Name __________________________ |
| Address ________________________ |
| ______________________________ |
| ______________________________ |
| ______________________________ |
| ______________________________ |
Is the Berlin questionnaire a useful tool to diagnose obstructive sleep apnea in the elderly?

- 643 patients completed the Berlin questionnaire and underwent at-home respiratory recording
- Presence of OSA was defined by an AHI > 15
- Did not provide a high level of diagnostic specificity to discriminate OSA in an elderly population

Is the Berlin questionnaire a useful tool to diagnose obstructive sleep apnea in the elderly?

- 202 subjects (31.4%) were in an OSA high-risk group according to the Berlin questionnaire
  - The high-risk subjects were significantly heavier, had greater waist and hip circumferences, higher AHI, and reported more frequently hypertension and diabetes.
- Being in the high-risk group predicted an AHI > 15 with a sensitivity of 77%, a specificity of 39%
- Positive predictive value of 63%
- Negative predictive value of 55%

Comprehensive Sleep Evaluation

- Witnessed apneas
- Snoring
- Gasping/choking at night
- Excessive daytime sleepiness
- Nonrefreshing sleep
- Total sleep amount
- Sleep fragmentation/insomnia
- Nocturia
- Morning headaches
- Decreased concentration
- Memory loss
- Decreased libido
- Irritability

Journal of Clinical Sleep Medicine, Vol. 5, No. 3, 2009
High Risk Patients

- Obesity (BMI >35)
- Congestive heart failure
- Atrial fibrillation
- Hypertension (treatment refractory)
- Pulmonary hypertension
- Type II Diabetes
- Stroke
- High risk occupations
- Nocturnal dysrhythmias
- Patients begin evaluated for bariatric surgery

Journal of Clinical Sleep Medicine, Vol. 5, No. 3, 2009
OSA independently associated with:

- Car crashes involving drivers who fall asleep
- Hypertension
- 4 year risk of development of hypertension
  - Peppard, et al. NEJM 2000; 342:1378-1384
- Myocardial infarction
- Cardiovascular events of all causes
  - Shahar, et al. AJRCCM 2001; 163:19-25
Signs

- Systemic hypertension
- Pulmonary hypertension
- Polycythemia
- Cor pulmonale
- Bradycardia during apneic event
- Tachycardia after airflow restored
- Typically no respiratory abnormality while awake
- Arterial blood gasses while awake may show metabolic alkalosis
Physical Exam Findings Suggestive of OSA

- Increased neck circumference
  - > 17 inches in men
  - > 16 inches in women
- BMI >30
- Modified Mallampati score of 3 or 4
- Retrognathia
- Lateral peritonsillar narrowing
- Macroglossia
- Tonsillar hypertrophy
- Elongated or enlarged uvula
- Nasal abnormalities
- High arched/narrow hard palate

Journal of Clinical Sleep Medicine, Vol. 5, No. 3, 2009
Mallampati Score

Class I

Class II

Class III

Class IV

Huang et al. BMC Gastroenterology (2011) 11:12
Anatomy of OSA

[Illustration of the anatomy of the oropharynx and laryngopharynx, highlighting the uvula, soft palate, epiglottis, nasopharynx, oropharynx, and laryngopharynx.]
This airway obstruction or partial obstruction manifests in:

- a reduction in airflow, termed hypopnea,
- OR
- a complete cessation of airflow, termed apnea

Despite ongoing inspiratory effort
Who should be tested?

- Any patient who snores and has excessive daytime sleepiness
- In the absence of excessive daytime sleepiness, diagnostic testing recommended if the patient snores **AND** has:
  - Two or more of the clinical features consistent with OSA
  - Or
  - Works in a mission-critical profession
    - airline pilots, bus and truck drivers
Diagnosis

- Gold standard is overnight polysomnography testing
- Variables that may be determined include:
  - EEG and electrooculogram (for sleep state); EMG
  - Airflow at nose or mouth (thermistor, pneumotachograph)
  - End-tidal CO2
  - Chest and abdominal motion
  - ECG
  - Blood pressure
  - Pulse oximetry
  - Esophageal pressure (intrapleural pressure)
  - Autonomic nervous system activity (finger tonometer)
Normal Polysomnograph

- EEG
- EMG
- ECG
- BP
- Abd
- Chest
- Vt (air flow)

Pulse Oxygen Saturation

100

75

Time (minutes)

20 sec
Obstructive Sleep Apnea

EEG

ECG

BP

Abd

Chest

Vt (air flow)

Pulse Oxygen Saturation

100

75

20 sec

Time (minutes)
Apnea

- The cessation, or near cessation, of airflow
  - It exists when airflow is less than 20 percent of baseline for at least 10 seconds in adults

- Can produce arousals from sleep, increased arterial carbon dioxide, and decreased oxygen levels

- Apnea is most commonly detected using sensors placed at the nose and mouth of the sleeping patient
Three Types of Apnea

- **Obstructive apnea** —
  - occurs when airflow is absent or nearly absent, but ventilatory effort persists
  - It is caused by complete, or near complete, upper airway obstruction

- **Central apnea** —
  - occurs when both airflow and ventilatory effort are absent
  - Breathing cessation is proven by an absence of diaphragmatic activation, measured by electromyography

- **Mixed apnea** —
  - an interval during which there is no respiratory effort (i.e., central apnea pattern) and an interval during which there are obstructed respiratory efforts
  - The central apnea pattern usually precedes the obstructive apnea pattern during mixed apnea
Respiratory effort related arousals

- A sequence of breaths that lasts at least 10 seconds
- Characterized by increasing respiratory effort or flattening of the nasal pressure waveform
- Leads to an arousal from sleep
- Does not meet the criteria of an apnea or hypopnea
- The inspiratory airflow or tidal volume is maintained during these episodes, but requires increased respiratory effort
- RERAs are often accompanied by a terminal snort or an abrupt change in respiratory measures
Hypoventilation

- Defined as an increase in the arterial carbon dioxide (PaCO2) of 10 mmHg during sleep (compared with an awake supine value) that lasts at least 25 percent of the sleep time.
- Directly measuring the pCO2 in an arterial blood gas during a sleep study is optimal, but impractical.
- Transcutaneous CO2 measurements and expired end tidal CO2 are alternatives.
- Sleep hypoventilation is usually presumed when persistent oxyhemoglobin desaturation is detected without an alternative explanation, such as apnea or hypopnea.
Polysomnography Indices

- **Apnea index** — is the total number of apneas per hour of sleep.

- **Apnea hypopnea index** — is the total number of apneas and hypopneas per hour of sleep.
  - The AHI is most commonly calculated per hour of total sleep.

- **Respiratory disturbance index** — is the total number of events (eg, apneas, hypopneas, and RERAs) per hour of sleep.
  - The RDI is generally larger than the AHI, because the RDI considers the frequency of RERA, while the AHI does not.
Polysomnography Indices

- Desaturation — a frequent consequence of apnea and hypopnea
  - Oxygen desaturation index - is the number of times that the oxygen saturation falls by more than 3 or 4 percent per hour of sleep

- Other measures that may be found in polysomnography reports include:
  - Fraction of sleep time spent at each level of oxygen saturation
  - The mean oxygen saturation

- Arousal index — is the total number of arousals per hour of sleep
  - It is generally lower than the AHI or RDI because approximately 20% of apneas or hypopneas are not accompanied by arousals that are evident on polysomnography
  - Arousals can be caused by periodic limb movements, noise, and sleep state transitions
OSA Definition

- More than 15 apneas, hypopneas, or RERAs per hour of sleep (an AHI or RDI >15 events/hr) in an asymptomatic patient
- OR
- More than 5 apneas, hypopneas, or RERAs per hour of sleep (an AHI or RDI >5 events per hour) in a patient with signs or symptoms
  - sleepiness, fatigue and inattention, snoring, restless sleep, and respiratory pauses
- More than 75% of the apneas or hypopneas must have an obstructive pattern
Differential Diagnosis

- Periodic limb movements of sleep — recurrent jerks of the legs and arms, associated with arousals
  - Often observed in association with OSA and can further fragment sleep, even after successful therapy for OSA
- Rotating shift workers — Night-shift workers obtain approximately seven hours per week less sleep than non-shift workers
  - Often revert to a daytime schedule on their leisure days, which adds to their sleep deprivation.
- Narcolepsy — Patients with symptoms suggestive of OSA may actually have narcolepsy
  - Sleep attacks are classically described
  - Many patients complain of ongoing drowsiness
- Upper airway resistance syndrome — arousals from sleep induced by airflow limitation due to increased upper airway resistance (respiratory effort related arousals)
  - Patients with UARS have few discrete respiratory disturbances (ie, apneas or hypopneas) or episodes of desaturation
  - Common in thin women with certain craniofacial abnormalities
  - Associated with other functional syndromes
How to test

- Attended, in-laboratory polysomnography
  - full-night (diagnostic only)
  - split-night (diagnostic and therapeutic)

- Unattended, in-home portable monitoring is a reasonable alternative for patients with a high likelihood of moderate or severe OSA
  - **AND** no comorbidities
  - The portable monitoring device must record airflow, respiratory effort, and blood oxygenation
  - Does not provided CPAP titration
For the diagnosis of OSA, portable monitoring should be performed only in conjunction with a comprehensive sleep evaluation.

Clinical sleep evaluations must be supervised by a practitioner with board certification in sleep medicine or an individual who fulfills eligibility criteria for sleep medicine certification examination.

May be used as an alternative to polysomnography for diagnosis of OSA in patients with a high pre-test probability of moderate to severe OSA.

Journal of Clinical Sleep Medicine, Vol. 5, No. 3, 2009
Who to treat

- The Centers for Medicare and Medicaid Services guidelines for reimbursement:
  - Apnea hypopnea index >15 events per hour
  - or
  - Between 5 and 14 events per hour and associated with:
    - excessive daytime sleepiness, impaired neurocognitive function, mood disorders, insomnia, cardiovascular disease (hypertension, ischemic heart disease), or a history of stroke
Types of therapy

- **Behavioral modification**
  - Weight loss, sleeping position, abstinence from alcohol and sedating drugs

- **Surgery for correctable obstructing lesion**
  - Examples = tonsillar hypertrophy, adenoid hypertrophy, or craniofacial abnormalities
  - Uvulopalatopharyngoplasty, laser-assisted and radiofrequency ablation
  - Septoplasty, rhinoplasty, nasal turbinate reduction, nasal polypectomy, palatal advancement pharyngoplasty, tonsillectomy, adenoidectomy
  - Trials have failed to consistently demonstrate a benefit from surgical therapy
Types of therapy

- **Oral Appliances**
  - Mandibular advancement or tongue retaining devices
  - Indicated for mild to moderate OSA (AHI 5-30) or patient refusal to use PAP
  - Contraindicated if AHI >30, frequent desaturations, or dental abnormalities
  - Oral appliances are generally less effective than positive airway pressure at improving the AHI and oxyhemoglobin saturation, although there is no difference in the impact on subjective daytime sleepiness
  - Patients often prefer oral appliances

Ruoff C, *Chest* (2011); 140; 1110-1111
Positive Airway Pressure

- CPAP
  - **Fixed CPAP** - delivers positive airway pressure at a level that remains constant throughout the respiratory cycle
    - Splints the upper airway open, preventing upper airway collapse during sleep
    - Patient must initiate every breath
  - **Autotitrating CPAP** - delivers an amount of positive airway pressure that varies during the night
    - With increased airway resistance, the delivered pressure gradually increases according to the algorithm until adequate patency is detected
    - After a period of sustained upper airway patency, the delivered level of pressure gradually decreases

- A meta-analysis (9 randomized trials, 282 patients; published in *Sleep* 2004) found that autotitrating and fixed CPAP equally improved daytime sleepiness and the AHI. Adherence was similar in both groups.
Positive Airway Pressure

- **BiPAP** - delivers a preset inspiratory/expiratory positive airway pressure
  - Provides additional ventilatory support by augmenting the tidal volume
  - The tidal volume is related to the difference between the IPAP and EPAP
  - Most also allow back up rate

- **Adaptive servo-ventilation** - provides a varying amount of inspiratory pressure pressure superimposed on a low level of CPAP
  - It can be helpful in patients who develop central apneas when treated with CPAP as well as in patients who require medications that can suppress respiration because it compensates for episodes of central apnea
Accessory Features to PAP

- Pressure relief — Expiratory pressure relief briefly lowers the delivered positive airway pressure reducing the uncomfortable sensation of breathing against high pressure
- Heated humidification - decreases the nasal resistance approximately 50%
- Pressure ramp - initiates PAP delivery at a low level, then progressively increases the PAP to the prescribed level over a duration of time
Types of Masks

Nasal

Full Face

Nasal Pillow

Nasal Prong

Hybrid

Oral

Total Face
PAP Masks

- Mask fitting is essential to increasing patient compliance and effectiveness of therapy

- Considerations:
  - Claustrophobia
  - Mouth breathers
  - Nasal congestion
Follow up

- Continued coverage of a PAP device beyond the first three months of therapy requires that the treating physician conduct a clinical re-evaluation and document that the patient is benefiting from PAP therapy.

- Documentation of clinical benefit is demonstrated by:
  - Face-to-face clinical re-evaluation by the treating physician with documentation that symptoms of obstructive sleep apnea are improved.
  - Objective evidence of adherence to use of the PAP device, reviewed by the treating physician.

- Adherence to therapy is defined as use of PAP ≥ 4 hours per night on 70% of nights during a consecutive 30 day period anytime during the first 3 months of initial usage.
Associated Comorbidities
Effects of Obstruction on Pulmonary Circulation and Right Ventricle

- Hypoxic and hypercapnic pulmonary vasoconstriction cause pulmonary hypertension
- Chronic nighttime hypoxia may cause erythropoiesis and polycythemia → increases blood viscosity
- Hypoxic pulmonary vasoconstriction + increased blood viscosity → pulmonary hypertension → increase right ventricular afterload
- Increased right ventricular afterload may lead to right ventricular hypertrophy and eventually cor pulmonale
Other effects of OSA

- Increased right atrial volume increases secretion of atrial natriuretic peptide from atrial myocytes, which increases sodium excretion, and stretches receptors that suppress ADH secretion from the posterior pituitary gland → Nocturia

- Hypoxia and hypercapnia during obstruction cause dilatation of cerebral blood vessels → Morning headache

- Repeated increases in sympathetic tone and systemic blood pressure during arousals may cause vascular remodeling and changes in endothelial function → Systemic Hypertension
Cardiovascular Disease and OSA

- Long-term cardiovascular outcomes in men with obstructive sleep apnoea-hypopnoea with or without treatment with continuous positive airway pressure: an observational study
  - Lancet 2005, by Marin, Carrizo, Vicente, and Agusti
- Prospective cohort study followed 1651 men for a mean of 10 years following polysomnography
- Patients with untreated severe OSA (AHI of 42) had a higher incidence of fatal and non-fatal cardiovascular events than untreated patients with mild-moderate OSA, patients treated with CPAP, simple snorers, and healthy participants
- Findings have been supported by numerous other studies
Arrhythmias and OSA

- In an observational study, 228 patients with a sleep related breathing disorder (RDI≥30) were compared to 338 control subjects (RDI <5)
  - Am J Respir Crit Care Med. 2006

- The sleep related breathing disorder group had a higher prevalence of:
  - Nocturnal atrial fibrillation - 4.8% vs 0.9%
  - Nonsustained ventricular tachycardia - 5.3% vs 1.2%
  - Complex ventricular ectopy – 25% vs 14.5%
Arrhythmias and OSA

Bradycardia and asystole during sleep are the most prominent and significant rhythm disturbances associated with OSA.

Result from enhanced vagal tone, rather than structural disease of the conduction system.

Activation of the parasympathetic nervous system may result from:
- Hypoventilation
- Hypoxemia
- Respiratory acidosis
- Vigorous inspiratory effort against a closed airway (Mueller's maneuver)
Stroke and OSA

- The largest study was a prospective cohort study that followed 5422 individuals without a history of stroke for a median of 8.7 years
  - Obstructive sleep apnea-hypopnea and incident stroke: the sleep heart health study
    - Am J Respir Crit Care Med, 2010
- Each one-unit increase in AHI in men was estimated to increase stroke risk by 6%
Obesity, Hypoventilation and OSA
Obesity Hypoventilation Syndrome

- Several mechanisms affect the interaction between obesity and the respiratory system, resulting in hypoxemia and progressive disability
- Excessive adipose accumulation of the chest and abdomen
  - Reduction in chest wall compliance
  - Reduction in respiratory muscle endurance due to increased resistance
  - Loss of expiratory reserve volume
- Mechanical overstretching of the diaphragm, reducing efficiency
- Increased upper airway resistance

Leptin and OHS

- Satiety hormone produced by adipocytes
- Stimulates ventilation
- Increased in obesity in response to hypercapnia and increased respiratory work load
- In patients with OHS the response to leptin is blunted suggesting leptin resistance
- When treated, OHS patient’s leptin levels decrease

Mokhlesi, B. *Respiratory Care* 2010, 55; 10: 1347-1365
Mechanism of Chronic Hypercapnia in OHS

- Obesity
  - Leptin resistance
  - Increased mechanical load and weak respiratory muscles
    - Blunted ventilatory response
      - Chronic hypercapnia
  - Obstructive sleep apnea
    - Upper-airway resistance
      - Acute hypercapnia during sleep
        - Increased serum $\text{HCO}_3^-$
          - Decreased CO$_2$ response
          - Decreased HCO$_3^-$ excretion rate
OHS Morbidity

- OHS patients were more likely to have:
  - Diagnosis of CHF
  - Angina pectoris
  - Cor pumonale
  - Increased severity of pulmonary hypertension
  - More hospitalizations and admission to ICU
- Tend to use more antihypertensives
- Higher insulin resistance requiring treatment with glucose lowering medications

Mokhlesi, B. *Respiratory Care* 2010, 55; 10: 1347-1365
OHS Mortality

- Death rate over 18 month period, 4x higher in patients hospitalized with untreated OHS than in patients with obesity and absence of OHS

OHS Mortality

- Early identification is key
- Studies suggest adherence to PAP lowers short-term mortality

Mokhlesi, B. *Respiratory Care* 2010, 55; 10: 1347-1365
Clinical Findings Suggesting OHS

- Large neck circumference
- High waist:hip ratios
- Elevated serum bicarbonate level
- Hypoxemia during wakefulness
- Secondary erythrocytosis
- Excessive daytime sleepiness
- Neurocognitive impairment
- Secondary pulmonary hypertension
Management of OHS

- **Weight loss**
  - Reduction of 10kg can lead to improvement in pulmonary physiology

- **Positive Pressure Ventilation**
  - Preventing obstructive events
  - Reducing work of breathing related to small airway closure and expiratory flow limitation

- **Oxygen supplementation** (inadequate as a single therapy)

- **Tracheostomy**

- **Pharmacotherapy**

*Sleep Med Rev 2011; 15:79-89*
Putting it all together...

- In obese patients it is important to recognize subtle, and often not so subtle signs and symptoms:
  - Snoring, excessive daytime sleepiness
  - Hypoventilation
    - Hypercapnia, elevated serum bicarbonate, erythrocytosis, check for hypoxia
  - Comorbid conditions
    - Ischemic heart disease, stroke, secondary pulmonary hypertension, HTN, arrhythmias, diabetes
- Test and treat early!