Overview of SDB

Types of sleep-disordered breathing (SDB)
- Obstructive sleep apnea (OSA)
- Central sleep apnea/Cheyne-Stokes respiration (CSA/CSR)

Diagnostics
- Screening tools/questionnaires (e.g., STOP-Bang, Berlin, ESS)
- Polysomnography (PSG)
- Home-based or in-laboratory testing

Therapeutic solutions
- PAP therapy
- Non-PAP methods (e.g., mandibular splints, nerve stimulation, body position, surgery)
Sleep Apnea – The Basics

Apnea-Hypopnea Index (AHI)
- Number of apneas and hypopneas per hour
- Apnea = cessation of flow for at least 10 sec
- Hypopnea = 30% reduction of flow for at least 10 sec with a 4% O₂ desaturation
- AHI < 5 (normal), AHI 5-14 (mild), AHI ≥15 (moderate/severe)

Oxygen Desaturation Index (ODI)
- Number of O₂ desaturations per hour
- Based on 4% drop for CAT-HF

Mechanism of Normal Breathing

Breathing is regulated by:
- Chemoreceptors that monitor blood gas levels CO₂ (primarily) and O₂ (secondarily)
- The respiratory control center in the brain

Mechanism of OSA

WHAT HAPPENS IN OSA PATIENTS:
- Airway is obstructed
- The level of CO₂ rises (O₂ level falls), signaling patient to breathe
Obstructive Sleep Apnea (OSA) Indicators

- Habitual loud snoring
- Witnessed apneas
- Hypertension
- Excessive daytime sleepiness
- Morning headaches
- Obesity/neck circumference
- Heart failure/CVD

Mechanism of CSA

WHAT HAPPENS IN CSA PATIENTS:

- Airway is open
- Because the level of CO₂ is below the patient’s apneic threshold, no signal is sent to breathe
Central Respiratory Events

Flow
Thorax
Abdomen
SaO₂

OSA

Flow
Thorax
Abdomen
SaO₂

CSR

Flow
Thorax
Abdomen
SaO₂

CSA

Treatment Theories for CSA/CSR

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oxygen</td>
<td>Modest reduction in apneas, but does not improve congestive heart failure</td>
</tr>
<tr>
<td>Addition of deadspace or rebreathing of CO₂</td>
<td>↓ events, but may ↑ minute ventilation; can cause respiratory acidosis; can ↑ arousals</td>
</tr>
<tr>
<td>Respiratory stimulants</td>
<td>↓ events but doesn’t ↑ SaO₂, ↓ arousals or improve sleep structure; many adverse side effects, specifically arrhythmias</td>
</tr>
<tr>
<td>Diamox</td>
<td>Results in acidosis and ↓ in ventilation while ↓ fluid retention</td>
</tr>
<tr>
<td>Sleep repositioning, encouraging non-supine positioning</td>
<td>May ↓ CSA, though improvements are likely to be seen only in NREM sleep</td>
</tr>
</tbody>
</table>
Pathophysiologic Effects of OSA

- Sleep fragmentation
- Neurohormonal imbalance
- Behavioral changes

Intrathoracic pressure changes:
- Overdistends R atrium and ventricle
- Shifts intraventricular septum to left
- Atelectasis
- Cardiac input

Desaturation (hypoxemia):
- ↑ Sympathetic response
- ↑ HR & ↑ BP
- Arrhythmias
- ↑ coagulability and clot formation
- Deoxygenation-reoxygenation causes endothelial dysfunction

Intrathoracic pressure:
- Doppler R atrium and ventricle
- Shifts intraventricular septum to left
- ↑ Afterload
- ↓ Cardiac output

Cardiovascular Disease

- Prevalence and Risk Factors

Cardiovascular Disease

- Depressive
- Heart failure
- Stroke
- Obesity

Type 2 Diabetes

- Drug resistant-hypertension
- Coronary artery disease

SDB Impacts Overall Health

- Depression
- Heart Failure
- Stroke
- Obesity

Type 2 Diabetes

- Drug resistant-hypertension
- Coronary artery disease

References Available Upon Request
OSA Prevalence in Cardiovascular Disease

- Drug Resistant Hypertension
- Congestive Heart Failure
- Pacemakers
- Atrial fibrillation
- All hypertension
- Coronary artery disease
- Angina

What is the Effect of the Untreated Sleep Apnea Patient?

- Untreated OSA group averaged 32% more hospital admissions than treated OSA group.
- Prior to diagnosis, OSA patients utilized medical resources 23-50% more than control group.
- Patients with untreated OSA had inpatient costs 82% higher than treated patients.
- CSA patients with heart failure had 6-month adjusted rate ratio of cardiac readmission of 1.53 compared to patients with no SDB.

Cardiovascular Disease Development

- OSA
- Disease Mechanisms
- Associated CV Disease

- Hypoemia
- Hypercapnia
- Hyperventilation
- Hypoxemia
- Metabolic dysregulation
- Neurohumoral activation
- Left atrial enlargement
- Endothelial dysfunction
- Hypercoagulability
- Hypertension
- Heart failure
- Atrial fibrillation
- Renal disease
- Stroke
- Myocardial infarction

Sudden Cardiac Death
Screening Process

Screening Tools to Assist You

Screening Questions
Nocturnal Oximetry
HST

CSA/CSR Identification

1. Review patient’s H & P
   - Evaluate for cardiac history (e.g., atrial fibrillation, CHF)
   - Review patient’s list of medications (look for CVD medications and/or narcotics)
   - Referring physician (e.g., cardiologist)
   - Look for a history of oxygen use, particularly nocturnal use

2. Identify central events from PSG

3. Identify Cheyne-Stokes (CSR) breathing pattern
   - Compress data to 120-300 sec for optimal detection
Screening for Obstructive Sleep Apnea (OSA)

- Do you snore?
- Are you excessively tired during the day?
- Have you been told you stop breathing during sleep?
- Do you have a history of hypertension?
- Is your neck size > 17 in (male) or > 16 in (female)?

"Yes" to two (or more) of these questions is a positive screen for OSA, physician should consider referral to sleep lab.

Screening for Central Sleep Apnea/ Cheyne-Stokes Respiration (CSA/CSR)

Patient Profile
- NYHA class III/IV / O2Sat below 89%
- Atrial fibrillation
- PaCO2 < 30 mm Hg
- Cheyne-Stokes respiration occurs during exercise stress test

If the patient meets one (or more) of the above conditions, continue with patient screening questions below:
- Have you experienced shortness of breath while lying flat on your back at night?
- Have you experienced a very event rate in the middle of the night?
- Do you regularly require long naps during the day?

"Yes" to one (or more) of these questions is a positive screen for CSA/CSR, physician should consider referral to sleep lab.

CSA/CSR Identification

1. Review patient's H & P
   - Evaluate for cardiac history (e.g., atrial fib, CHF)
   - Review patient's list of medications (look for CVD medications and/or narcotics)
   - Referring physician (e.g., cardiologist)
   - Look for a history of oxygen use, particularly nocturnal use

2. Identify central events from PSG

3. Identify Cheyne-Stokes (CSR) breathing pattern
   - Compress data to 120-300 sec for optimal detection
**HST Provides Easy-to-Interpret Results**

- Screening downloadable to PC and auto-analyzed (adjustable criteria for analysis)
- Simple yet comprehensive one-page report includes:
  - AHI
  - Oxygen saturation statistics
  - CSR detection
- Apnea and hypopnea scored to AASM/CMS definitions

**Positive Airway Pressure (PAP) Therapy**

1) CPAP

2) Bilevel (VPAP™)

3) Minute ventilation adaptive-servo ventilation (MV ASV)

**What About Positive Airway Pressure (PAP) Therapy for CSA/CSR?**

- CPAP and bilevel therapies are very effective at keeping airway patent to abolish the obstructive events
- Mixed results when studying CPAP therapy on central events
- Minute ventilation adaptive-servo ventilation (MV ASV) has shown very positive improvement in CSA/CSR patients
  - AHI
  - arousals
  - sleep quality
  - adherence to treatment
  - LVEF

Why Bilevel Therapy is Often Ineffective

CSA/CSR pts have low CO₂

Bilevel, with varying levels of Pp increases ventilation

Breathing increases, CO₂ levels drop further

CSA/CSR persists or worsens

Adaptive Servo-Ventilation (ASV)

• The VPAP™ Adapt offers ResMed’s unique minute ventilation adaptive servo-ventilation (MV ASV) therapy

• VPAP Adapt is a highly evolved bilevel device specifically designed to treat OSA, CSA, mixed apneas and periodic breathing

• Cleared by the FDA for the treatment of:
  - CSA (pure or idiopathic)
  - Mixed apneas (CSA + OSA)
  - Periodic breathing (CSR)

Why MV ASV?

• Refers to the device function via its MV ASV algorithm

• Adapts to changing patient needs

• Servo-ventilation because the pressure support is proportionally adjusted to treat CSA
The Basis of ASVAuto

- Central apneas - Stabilize minute ventilation
- Obstructive apneas - Flow limitation - Snore - Obstructive apnea

ResMed's ASV

ResMed's ASVAuto

ResMed's AutoSet™

ResMed's ASV is More Responsive

- In ResMed's ASV therapy, pressure support (PS) responds instantaneously to changes in minute ventilation
- In ASVAuto mode, EPAP responds on the next breath to flow limitation, snore and obstructive apneas

<table>
<thead>
<tr>
<th>Response</th>
<th>Responds to</th>
<th>Response time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure support</td>
<td>Minute ventilation</td>
<td>Instantaneously</td>
</tr>
<tr>
<td>EPAP</td>
<td>Flow limitation - Snore - Obstructive apnea</td>
<td>On the next breath</td>
</tr>
</tbody>
</table>

ResMed's ASV is More Comfortable

- Easy Breathe waveform replicates the natural wave shape of normal breathing
- Learns, predicts and synchronizes with patient’s own breathing pattern
ASV responds to changes in minute ventilation
- Monitors recent average minute ventilation (~3-min window)
- It continuously calculates a target ventilation throughout the night (90% of recent average ventilation)
- Adjusts pressure support up or down as needed to achieve target

Obstructive Apnea Response in ASVAuto
Scenario 1: Obstructive Apnea
- Flow drops
- MV drops
- PS increases
- No/less flow, vent
- Airway = closed
- EPAP increases on next breath

Scenario 2: No Effort
- Flow drops
- MV drops
- PS increases
- Flow & vent egress
- Airway = open
- PS ventilates patient
- No change in EPAP

Central apnea converted to hypopnea eliminates need for central sleep apnea detection (CSAD)

A NOVEL TREATMENT FOR CHEYNE–STOKES RESPIRATION IN HEART FAILURE

Study
- n = 14 Stable Heart Failure (NYHA III) with CSA/CSR
- Method: Diagnostic PSG, all patients randomized
- 4 treatment nights (O2, CPAP, bilevel ST, ASV)

Results
- ASV ↓ AHI more than other 3 therapies
- ASV ↓ CAI and arousals more than other 3 therapies
- ASV ↑ slow wave + REM% (sleep quality)
- More patients preferred ASV

Teschler et al. Am J Respir Crit Care Med 2001
MV ASV Normalizes Breathing and Sleep Parameters

Study
Included 21 patients with varied diagnoses (CSA/CSR, mixed apneas, CompSA):
- AHI = 51.9
- RAI = 45.5

Findings
CPAP:
- AHI = 34.3
- RAI = 32.1

Bilevel ST:
- AHI = 6.2
- RAI = 6.4

ASV: (Treatment: AHI and RAI were both significantly lower using ASV, P<0.01)
- AHI = 0.8
- RAI = 2.4

Conclusion
Data confirms that in patients with CSA/CSR, mixed apneas and CompSA, both noninvasive positive pressure ventilation (NPPV) and ASV are effective in normalizing breathing and sleep parameters, and that ASV does so more effectively than NPPV in these types of patients.

MV ASV in CPAP Mode
CSR Pattern
SpO2 variable 90-98%
Pulse rate variable 77-81 beats per min

Switch from CPAP to ASV mode
Respiratory pattern beginning to normalize
Less variability in pulse rate
SpO2 stabilizing
ResMed's ASV Provides More Ease of Care

ASV mode:
Same default settings provide seamless transition for current ASV users

ASVAuto mode:
Appropriate for healthcare providers wishing to set patients up with auto-adjusting EPAP

CardioSource SDB Site
http://apnea.cardiosource.org

Sponsored by ResMed