Advanced Positive Airway Pressure Modes

David Schulman, MD, MPH, FCCP
Associate Professor of Medicine
Emory University School of Medicine
Atlanta, Georgia

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David A. Schulman
Personal/Professional Financial Relationships with Industry

<table>
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<th>External Industry Relationships</th>
<th>Company Name</th>
<th>Role</th>
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<tr>
<td>Equity, stock, or options in biomedical industry companies or publishers</td>
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<td>Board of Directors or officer</td>
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<td>Royalties from Emory or from external entity</td>
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<td>Industry funds to Emory for my research</td>
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<td>Other</td>
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“I did not have improper relations with that company.”
Learning Objectives

• By the end of this presentation, attendees should be able to:
  – Describe different positive airway pressure modes, including CPAP, autotitrating CPAP, bilevel PAP, adaptive servo ventilation, and average volume-assured pressure support.
  – Identify appropriate patients for each of the modes above.
  – Indicate parameters for appropriate implementation of each of the modes above.

Spontaneous ventilation vs. CPAP
Indications for CPAP therapy

- CHF / COPD exacerbation (inpatient)
- OSA (outpatient)

Why does CPAP acutely improve oxygenation?

- Elevated mean airway pressures
  - Less likely to develop alveolar collapse
    - Less areas of shunting and poor V/Q mismatch

- Increased intrathoracic pressures lead to decreased venous return in CHF

- Elevated functional residual capacity leads to:
  - More open alveoli exchanging oxygen
The effect of auto-PEEP

Application of external PEEP will decrease work of breathing

Allows inspiratory flow with less negative inspiratory force
Why CPAP for OSA?

Normal airway anatomy

Retropalatal airway

Retroglossal airway

OSA patient  Normal patient
Effect of CPAP

Methods of CPAP administration
CPAP (E0601) coverage

• Face-to-face clinical evaluation prior to testing
• Instructed about appropriate use of therapy
• One of the following criteria:
  – 1. The apnea–hypopnea index (AHI) or respiratory disturbance index (RDI)* is ≥ 15 events per hour with minimum of 30 events; or
  – 2. The AHI or RDI is ≥ 5 and ≤ 14 events per hour with minimum of 10 events and documentation of:
    a. Excessive daytime sleepiness, impaired cognition, mood disorders or insomnia; or
    b. Hypertension, ischemic heart disease or history of stroke.

Risks of CPAP

• Discomfort
• Gastric distension / bloating
• Facial reaction
• Dry mouth
• Congestion, runny nose, sneezing, sinusitis, nosebleeds
CPAP and Bilevel PAP

Bilevel PAP – IPAP/EPAP  Expiratory pressure relief:
Brief drop in pressure

The benefits of inspiratory pressure

[Graphs and diagrams showing CPAP and Bilevel PAP]
Indications for bilevel pressure

• Discomfort with CPAP
  – ? Better than expiratory release?

• Hypoventilation
  – Restrictive disorders, COPD, Neuromuscular dz

• Central or “complex” sleep apnea associated with hypercapnia
  – Particularly time-cycled

Central Sleep Apnea

• A diagnosis of central sleep apnea (CSA) requires all of the following:
  – An apnea hypopnea index > 5
  – Central apneas/hypopneas > 50% of the total apneas/hypopneas
  – Central apneas or hypopneas ≥ 5 times per hour
  – Symptoms of either excessive sleepiness or disrupted sleep
Complex Sleep Apnea

• Persistence or emergence of central apneas or hypopneas upon exposure to CPAP when obstructive events have disappeared

• These patients have predominately obstructive or mixed apneas during the diagnostic sleep study occurring at ≥ 5 times per hour

Bilevel (E0470) coverage for OSA

• A single-level CPAP device has been tried and proven ineffective based on a therapeutic trial.

• An appropriate interface has been properly fit and the beneficiary is using it without difficulty.

• The current pressure setting of the CPAP prevents the beneficiary from tolerating the therapy; lower CPAP settings failed to:
  – 1. Adequately control the symptoms of OSA; or
  – 2. Improve sleep quality; or
  – 3. Reduce the AHI/RDI to acceptable levels.
Problems with bilevel pressure

- Higher pressure = more leak
  - Tighter mask = greater likelihood of cutaneous reaction
- Overventilation

Case #1

- 67 year-old man c/o snoring, ESS 14
  - 5’10”, wt 195 lbs
  - OSA dxed 2005 (RDI 34)
  - Prescribed CPAP 10 cm H2O (residual RDI 0.4)
    - Complained of suffocation
  - Dropped to 8 cm H2O (RDI 4.2) with improved tolerance and subjective benefit (ESS 9)
Lost to follow-up til ‘09

- Hospitalized for motorcycle accident
  - Denies sleepiness as a contributor (ESS 7)
- Still c/o suffocating sensation
  - Stopped CPAP without notification in ‘08
  - Converted by a helpful internist to bilevel pressure 11/7 cm H2O
  - Tolerance markedly improved to 6X/wk
  - ESS 5

First month back on therapy
Compared with controls, OSA patients:

Have a lower ETCO2 during sleep

Therefore, live closer to their apneic threshold

Have a similar apneic threshold

In sum, have a heightened chemosensitivity

Salloum et al, AJRCCM 2010; 181: 189-93.
Treatment-emergent Central Sleep Apnea

- Development of CSA during therapy for OSA
  - Unmasking previously-existing CSA
  - Overtitration of CPAP
    - Hering-Breuer reflex
    - More effective ventilation with relief of obstruction
- Can occur with other forms of therapy as well!


Autotitrating machines

- CPAP (or bilevel) machine that modify their settings based upon an assessment of the quality of respiration

- Can be used:
  - In lieu of CPAP titration
  - Comfort
  - Allows pressure to change with changes in weight or disease severity
AutoPAP

Device responds to flow limitation:
- Increases pressure till stable
- Reduces pressure after defined period

Auto Bilevel PAP
Are Autotitrating Machines Better than CPAP?

- APAP is associated with a reduction in mean PAP by 2.2 cm of water c/w CPAP (averaged over the night) – Ayas (2004)
- APAP yields improvement in SF-36 scores but not ESS – Massie (2003)
- APAP generally reduces the AHI < 10 (80-95% of patients) – is this enough? (Berry 2002)

56 year-old man with (presumed) chronic and severe OSA
- Admitted to MICU for respiratory failure, intubated
- Initial ABG on 50% FiO2 7.28 / 65 / 90

- Morbidly obese, mild CHF (EF 40%), HTN, type 2 DM
- Lengthy hx heroic snoring, breathing pauses, never evaluated
- No sign of acute infection

Case #2
Hospital stay

- After difficulty weaning (and agitation during trials), undergoes tracheostomy and rapidly weaned from the vent

- On discharge, trached but not oxygen requiring
  - ABG 7.37 / 52 / 65 (ambient air)

- ? Bilevel pressure vs. CPAP vs. no therapy (since presumed OSA “cured”)

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PSG (tracheostomy plugged)

5 minute epoch
PSG (tracheostomy open)

5 minute epoch

Better Treatment Options for CSA (?)

• Adaptive support ventilation
• Average volume assured pressure support
Adaptive Servo Ventilation

ASV adjusts the magnitude of pressure support breath by breath to counterbalance the shift between hyperventilation and hypoventilation and thus overcomes the ventilatory overshoot.

Volume Assured Pressure Support

- Adjusts pressure support to maintain a set ventilation

  Average Volume Assured Pressure Support (AVAPS)
  - targets a preset tidal volume

  Intelligent Volume Assured Pressure Support (IVAPS)
  - targets alveolar ventilation
Case #3

- A 50 year-old male heart failure patient with recently ablated atrial fibrillation presents with a history of snoring, witnessed apneas, and daytime sleepiness.
- Epworth sleepiness score of 16/24.
- Echocardiogram showed ejection fraction of 15-20%
AHI was 72.3/hour – 25 central apneas – 13 mixed apneas – 62 hypopneas – Minimum oxygen saturation of 79%.

This pattern is seen throughout study except in REM.

What would you do next?

A. CPAP titration
B. AutoPAP titration
C. Bilevel PAP ST titration
D. Identify and treat any medical contributors
E. Adaptive Servo Ventilator titration (ASV)
We decide to switch to ASV titration

ASV started here

ASV is relatively contraindicated in which of the following?

A. Cheyne-Stokes respiration with heart failure
B. Long acting opiates with central sleep apnea
C. Treatment-emergent central sleep apnea
D. Obesity hypoventilation with central sleep apnea and hypopneas
Two Different ASV Machines

VPAP Adapt
- Variable inspiratory support is given to maintain the target ventilation (90% of recent average ventilation)
- Variable learned backup rate

BiPAP auto SV Advanced
- Variable inspiratory support is given to maintain the average peak flow over the prior 4 minutes
- Auto backup rate will not allow patient to go below 8 BPM
- Clinician can also set backup rate

Prescription Settings

VPAP Adapt (ASV mode)
- EPAP
- PS min (lowest 3 cmH2O)
- PS max

VPAP Adapt (ASVauto mode)
- EPAP min/max
- PS min (lowest 0 cmH2O)
- PS max

BiPAP auto SV Advanced
- EPAP min/max
- PS min (lowest 0 cmH2O)
- PS max
- Max Pressure
- Rate: Auto or BPM
- I-Time (with fixed rate)

PS = pressure above EPAP min at all times in VPAP Adapt ASVauto mode
Case #4

• 63 year-old woman
• Long-standing diagnosis of kyphoscoliosis
  – Used body cast throughout primary and secondary schooling
• Presents now with 1-2 years of worsening dyspnea on exertion and pedal edema

Case #4

• PFTs reveal severe restriction
• Echocardiogram demonstrates probable pulmonary hypertension with dilated RV
• ABG: pH 7.41, pCO2 77, pO2 56
• Husband also notes intermittent snoring
• Patient reports frequent AM headaches
• PSG performed on 1lpm supplemental O₂
Trace Overviews from PSG

Patient goes to bathroom

AHI = 5.2

What would you do next?

A. CPAP
B. Bilevel PAP
C. Bilevel PAP with backup rate
D. Adaptive servoventilation
E. Volume assured pressure support
Patient referred for sleep study due to sleepiness; PSG shows OA, OH, CA, RERA

- Normal echo 9 months ago
- PMH: depression, hyperlipidemia
- Meds: simvastatin, venlafaxine
- BMI 27.4
What do you do next?

A. Re-evaluate medication list
B. Repeat echocardiogram
C. Do an autoPAP trial
D. Start CPAP and re-evaluate in one month
E. Bring in for ASV titration
F. A + C
G. A + E

48 year old male with chronic low back pain on fentanyl patch (100 mcq)
What would you do next?

A. Change fentanyl to methadone at equivalent dosing
B. Send to pain clinic for dosage reduction
C. CPAP titration
D. AVAPS titration
E. ASV titration