Auto Servo Ventilation – Indications, Basics of Algorithm, and Titration
ASV Learning Objectives

• Understand the indications for Auto Servo Ventilation
  – Differentiate obstructive versus central hypopneas

• Understand the basics of the BiPAP autoSV algorithm

• Understand ASV titration
Indications for ASV

- Central Apnea/Central Hypopnea
- Complex Apnea
- Cheyne Stokes Respiration
Indications for ASV

Central apnea (for any reason)

...may include:

1. Central sleep apnea-hypopnea associated with narcotic use or brainstem lesions.
   These may be due to:
   – Disturbances of the central respiratory center
   – Peripheral chemoreceptors “gone awry”
2. **Complex Sleep Apnea**

Complex Sleep Apnea occurs when a patient being treated for Obstructive Sleep Apnea develops Central Sleep Apnea when Continuous Positive Airway Pressure (CPAP) is administered.
3. Cheyne-Stokes Respiration (often associated with heart failure)

Often, heart failure patients display sleep-disordered breathing in the form of Cheyne-Stokes Respiration (CSR). CSR is a periodic breathing disorder characterized by an alternating pattern of waxing and waning tidal volumes with periods of central apnea or central hypopnea along with deep, rapid breathing (hyperventilation).

- CSR often disappears in REM sleep.
- In CSR, arousals typically occur at the period of deepest breathing, or highest airflow point (hyperpnea or waxing).
What do you see?
What do you see?
What do you see?
What do you see?
What do you see?

Note square wave pattern of OSA recovery breathing. Different from CSR.

Note difference in oximetry pattern.
What do you see?

Centrally mediated events tend to improve during REM sleep. Obstructive events get worse.

SDB goes away in REM. Is this pattern more likely OSA or CSR?
Central or obstructive hypopnea? Likely response to CPAP?
Periodic breathing (CSR)  Polysomnography

Oximetry

REM Sleep
There are two brands of ASV machines out there right now:

- ResMed VPAP Adapt SV
- Respironics BiPAP autoSV Advanced
BiPAP autoSV ADVANCED: What is it?

REMstar Auto CPAP +
Advanced Apnea Detection

Auto EPAP

ASV Algorithm
(Varying PS levels and Auto Backup Rate)

Bi-Flex

= BiPAP autoSV ADVANCED
BiPAP autoSV Advanced algorithms

- Treats events with 3 different support functions.
  - EPAP to maintain upper airway stability during sleep (treats obstruction)
  - Inspiratory support for patients with unstable or fluctuating tidal volumes or breathing patterns (varying PS levels)
  - Back up breath rate for central apnea
– Clinically-proven SV algorithm monitors peak flow during a 4 minute moving window and changes pressure support (IPAP levels) breath by breath to stabilize the breathing pattern.

– By establishing a targeted peak flow, the SV algorithm can rapidly normalize unstable breathing patterns with quick adjustments of pressure support.

– The automatic back-up respiratory rate feature kicks in as needed.
Terms to Learn for ASV

- **EPAPmin**
  - The EPAP will not drop below this pressure

- **EPAPmax**
  - The EPAP will not go above this pressure even if events are detected
  
  Responds to ALL obstructive events - OA, OH, Snores

- **Psmin**
  - The minimum amount of pressure support (i.e. minimum difference between the EPAP and the PSmmin setting)

- **PSmax**
  - The maximum amount of pressure support (i.e. maximum difference between the EPAP and the PSmax)
Pressure Support- Difference between IPAP and EPAP (IPAP – EPAP)

<table>
<thead>
<tr>
<th>If EPAP is ..</th>
<th>And PSmin is ....</th>
<th>What is the IPAP?</th>
<th>BiLevel setting?</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>4</td>
<td>8</td>
<td>8/4</td>
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<td>6</td>
<td>5</td>
<td>11</td>
<td>11/6</td>
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<tr>
<td>6</td>
<td>0</td>
<td>6</td>
<td>6/6.....CPAP</td>
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<tr>
<td>9</td>
<td>3</td>
<td>12</td>
<td>12/9</td>
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</tbody>
</table>
Pressure Support

- **Psmin**
  - The minimum amount of pressure support (i.e. minimum difference between the EPAP and the PSmin setting)

- **PSmax**
  - The maximum amount of pressure support (i.e. maximum difference between the EPAP and the PSmax)

Responds to all decreases in flow
What does Pressure Support do?

• It’s the ASV or the **Automatic**, Servo-Ventilation component
  – Min and Max pressures - Auto
• It’s function? Make all flow patterns look just alike….

[Diagram showing baseline flow and pressure changes with annotations:]
- Baseline flow
- Recognizes decrease
- Responds by increasing pressure support to bring flow waveforms up to previous levels
But…..That looks like an obstructive hypopnea!?

- Auto EPAP responds to obstructive hypopneas
- Pressure Supports responds to decreased flow
  (central apneas and central hypopneas)

How does the machine tell the difference?
First Mechanical Response

During the time of decreased flow, the Servo Ventilation algorithm, will attempt to ‘fix’ the hypopnea by increasing PS.
What happens next?

- The machine tries to increase pressure support.
  - If the airway has obstruction, the increase in PS is “blocked” and prevents ASV from making waveforms look the same.
AUTO EPAP increases pressure to open the obstructed airway!
Max Pressure

- **Max pressure**
  - The maximum pressure the device will deliver even if the algorithm indicates a pressure increase is needed

- If Set too low, this value may limit the amount of Inspiratory Pressure delivered.

Ex:  *EPAP rose to 10, PS rose to 10, that would be a Bipap of 20/10, if Max set below 20, this would limit the amount that needs to be given to the patient.*
OSA Titration

• Titrate to worse case scenario

• Patient usually requires higher pressures while supine and/or during REM

• Fixed pressure setting is normally prescribed at the level that resolves supine/REM events
OSA AutoPap Titration

• Set the patient on a minimum and maximum pressure
  – Wide open is 4 -20cm
  – After a few days, or weeks the machine is downloaded
  – Settings are adjusted based on download information and clinical progress
Treatment options for complex sleep apnea

• CPAP with time on therapy to reset chemoreceptors for patient\(^1\)
  – Must qualify with RDI > 5 with symptoms of OSA or RDI > 15 without symptoms \(^2\)
  – 30-day trial on CPAP then follow up with patient on excessive daytime sleepiness, if improved keep on CPAP

• No improvement in daytime sleepiness after 30 days, try alternatives
  – Medications + CPAP
  – Auto Servo Ventilation
  – Bi-Level therapy with backup rate
    • RAD policy for complex sleep apnea

\(^1\) Dernaika T et.al; Chest 2006 s;130(4)129
\(^2\) Adult Sleep Apnea Task Force, AASM, ; Journal of Clinical Sleep Medicine 2009; 5(3)
What’s the MAIN POINT of ASV titration?

- EPAP is increased to treat obstructive events and snoring

- Pressure Support levels and Back Up Rate work together by adjusting automatically to treat central apneas and central hypopneas
Min/Max EPAP

Most cases of central sleep apnea/hypopnea present with some degree of obstruction. Maintaining an open airway is vital to any PAP titration.

• EPAP addresses the obstructive component.

• Increase EPAP min only as needed to maintain an open airway - for Obstructive Apneas, Obstructive Hypopneas, and Snoring. BiPAP autoSV does this extremely well automatically when a range of EPAP is set.

• Techs must verify that the patient is actually snoring and it is audible and real. Often times the very quick pressure support changes can make sounds or vibrations that are picked up on the snore sensor. These “snores” are not an indication of obstruction and therefore EPAP should not be raised.
How to determine when a snore is not a snore?

When the only time snoring is present on the raw data is when the patient is not generating spontaneous breathing effort (belts are very reduced or flat). This usually represents “machine breaths” at the maximum pressure support levels.
Oh yeah…

EPAP is increased to treat obstructive events and REAL snoring!

Back-up Rate and Pressure Support levels treat central apneas and central hypopneas.
So how are we going to treat central apneas and central hypopneas?
Central events are treated with:

1. Pressure Support levels

2. Back-up Rate
Do techs typically have to play around with the pressure support levels and back up rates in ASV titrations?
NO!

This is because ASV machines auto-titrate pressure support levels and back up rates very effectively.
This has been a challenge for centers I have been associated with and likely for other centers as well. Know your center’s policy to assure that you are documenting in a clear manner to all involved (other techs, scoring techs, sleep specialists).
Servo ventilation patient types

- OSA
- COPD
- Periodic breathing
- Complex SDB
- Obesity hypoventilation
- Neuro-muscular disorders and SDB
- Restrictive disorders (e.g., kyphosis or fibrosis)
Terms you *need* to understand

- **EPAPmin** – The EPAP will not drop below this pressure
- **EPAPmax** – The EPAP will not go above this pressure even if events are detected
- **Max Pressure** – The maximum pressure the device will deliver even if the algorithm indicates a pressure increase is needed
- **Peak Inspiratory Pressure (PIP)** – The maximum pressure reached on inspiration to deliver the pressure support determined by the algorithm
- **Psmin** – The minimum amount of pressure support delivered each breath (i.e. minimum difference between the EPAP and the Psmin setting)
- **Psmax** – The maximum amount of pressure support that can be delivered (i.e. maximum difference between EPAP and the PIP)
BiPAP autoSV Advanced Titration Protocol

**Titration Goals:**

- Airway management, stabilize breathing patterns
  - by
  - monitoring patient’s response
  - and
  - adjusting user set parameters if needed
- for
- optimal therapy efficacy and adherence
autoSV acclimation zone

GOAL: Adjust user-set parameters for optimal efficacy and adherence

- Set mode to BiPAP autoSV Advanced

- Establish initial settings as indicated below or as ordered by physician
- Ensure proper mask fit to allow algorithm to work effectively
- Have patient breathe on autoSV Advanced at basic settings below
- Adjust EPAP$_{\text{min}}$, Bi-Flex and PS$_{\text{min}}$ settings to patient comfort

<table>
<thead>
<tr>
<th>EPAP$_{\text{min}}$</th>
<th>Max pressure</th>
<th>4 cm H$_2$O$^*$</th>
<th>25 cm H$_2$O</th>
</tr>
</thead>
<tbody>
<tr>
<td>EPAP$_{\text{max}}$</td>
<td>Rate</td>
<td>15 cm H$_2$O</td>
<td>auto</td>
</tr>
<tr>
<td>PS$_{\text{min}}$</td>
<td>Bi-Flex</td>
<td>0 cm H$_2$O</td>
<td>To patient</td>
</tr>
<tr>
<td>PS$_{\text{max}}$</td>
<td></td>
<td>20 cm H$_2$O</td>
<td>comfort</td>
</tr>
</tbody>
</table>

*If patient has known CPAP pressure of < 10 set EPAP$_{\text{min}}$ at 4 cm H$_2$O or patient comfort

*If patient has known CPAP pressure of > 10 set EPAP$_{\text{min}}$ at 6-8 cm H$_2$O or patient comfort
AutoSV titration zone

Monitor patient PSG
Wait… Watch… Observe… Think
Patience is the key to successful titration

At lights out observe for patient’s inability to maintain sleep due to severe obstructive apneas
At lights out observe for indications of therapy intolerance
Observe for peak inspiratory pressure being limited by $P_{S_{\text{max}}}$
Observe for inadequate breathing rate

If yes
If yes
If yes
If no
If no
If yes
If no

For patient comfort and to allow sleep onset increase EPAP$_{\text{min}}$ to open the airway
For patient comfort and to allow sleep onset adjust Bi-Flex settings or increase PS$_{\text{min}}$
Observe for:
1. Leak: fix mask leak
2. Obstructive events: increase EPAP$_{\text{min}}$
3. Central events: increase PS$_{\text{max}}$
Set fixed rate to a minimum 8-10 bpm or 2 below resting respiratory rate including apneas; set I-Time for 1.5 seconds

Wait a minimum of 20 minutes to assess effect before making another change.

Return to
Return to
Return to
Return to
Remember!

EPAP is increased to treat obstructive events and snoring.

Back-up Rate and Pressure Support levels treat central apneas and central hypopneas.