Mecanisme d’acció de la CPAP

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OUTLINE

Upper airway collapsibility in Obstructive Sleep Apnea (OSA)

Continuous Positive Nasal Pressure (CPAP) to treat OSA

Static and dynamic upper airway obstruction in OSA

Non-continuous nasal pressure to treat OSA

Intelligent CPAP systems: Automatic CPAP

Automatic CPAP: Bench testing

Automatic CPAP: Patient studies
CPAP in the treatment of sleep apnea. Fixed and intelligent systems.

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The fact that all the symptoms and consequences of OSA disappear by the simple application of a positive nasal pressure clearly shows that the mechanics of the upper airway plays a central role in the pathophysiology of OSA.

The pathophysiology of OSA is not fully understood. However, there is ample evidence that recurrent obstruction of the upper airway during sleep is the event determining the patient’s symptoms and is the cause of the long term systemic consequences.

The fact that all the symptoms and consequences of OSA disappear by the simple application of a positive nasal pressure clearly shows that the mechanics of the upper airway plays a central role in the pathophysiology of OSA.
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Upper airway collapsibility in Obstructive Sleep Apnea (OSA)

Farré et al., Eur Respir J, 2000

**PARTIAL OBSTRUCTION**

Hypopnea

Farré et al., Am J Respir Crit Care Med, 2002

Snoring
CPAP in the treatment of sleep apnea. Fixed and intelligent systems.

Upper airway collapsibility in Obstructive Sleep Apnea (OSA)

Navajas et al., Am J Respir Crit Care Med, 1998
Upper airway collapsibility in Obstructive Sleep Apnea (OSA)

**OSAHS**

**NORMAL**
Upper airway collapsibility in Obstructive Sleep Apnea (OSA)

**OSAHS**

**NORMAL**

CPAP in the treatment of sleep apnea. Fixed and intelligent systems.
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Upper airway collapsibility in Obstructive Sleep Apnea (OSA)

**OSAHS**

- EEG
- Flow (l/s)
- Pes (cmH₂O)
- Pa (mmHg)

**NORMAL**

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Static and dynamic upper airway obstruction in OSA:

**Critical pressure (static obstruction)**

**Upstream resistance (dynamic obstruction)**

CPAP in the treatment of sleep apnea. Fixed and intelligent systems.

Static and dynamic upper airway obstruction in OSA:

$P_{\text{crit}}$ (static obstruction) and $R_{\text{up}}$ (dynamic obstruction) are independent
Static and dynamic upper airway obstruction in OSA:

$P_{\text{crit}}$ depends on upper airway wall properties

$R_{\text{up}}$ depends also on gas properties

CPAP in the treatment of sleep apnea. Fixed and intelligent systems.

Static and dynamic upper airway obstruction in OSA:

- $P_{\text{crit}}$ does not depend on gas properties (only on upper airway wall properties)
- $R_{\text{up}}$ depends also on gas properties

Static and dynamic upper airway obstruction in OSA:

*Static obstruction ($P_{crit}$) and dynamic obstruction ($R_{up}$) are independent*


![Graph showing CPAP and obstruction parameters](image-url)
CPAP in the treatment of sleep apnea. Fixed and intelligent systems.

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Non-continuous nasal pressure to treat OSA

Different variants of non-continuous positive nasal pressure have been proposed to normalize the upper airway in OSA.

The most widely used in some subpopulations of OSA patients is bi-level pressure.
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For a given patient, $P_{\text{crit}}$ and $R_{\text{up}}$ depend on several factors (sleep stage, body posture, etc.). Accordingly, the $CPAP_{\text{opt}}$ to treat the patient may vary between nights and within the same night.

The concept of automatic CPAP consists on using an intelligent device capable of detecting breathing disturbances and to apply the nasal pressure required to normalize ventilation.
Although the concept of automatic CPAP is simple (to adjust nasal pressure to patient requirements), its practical implementation is difficult.

As the algorithm in autosetting CPAP devices must operate with a considerable number of variables, these devices are very complex.
APAP devices are based on three complementary but conceptually different software sections devoted to:

a) **detection of respiratory disturbances** (apneas, hypopneas, flow limitations, snoring, etc),

b) **identification of artifacts** (sighs, swallowing, cough, speaking, arousals, mouth breathing, air leaks, etc),

c) **modification of nasal pressure** in accordance with event and artifact detection.
The performance of an automatic CPAP device can be tested in the bench by connecting it to a breathing waveform generator reproducing realistic well-defined breathing patterns representative of patients with SAHS.
Bench testing is therefore useful:

- to test whether a given device behaves according to the defined strategy to adjust CPAP to the breathing pattern.

- to compare the response of different devices when they are subjected to exactly the same patterns of disturbed breathing.
CPAP in the treatment of sleep apnea. Fixed and intelligent systems.

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Rigau et al. *Chest* 2006;130; 350-361
CPAP in the treatment of sleep apnea. Fixed and intelligent systems.

Automatic CPAP: Bench testing

Rigau et al. Chest 2006;130; 350-361
Automatic CPAP: Bench testing

Obstructive apneas

Non-obstructive apneas

Rigau et al. Chest 2006;130; 350-361
CPAP in the treatment of sleep apnea. Fixed and intelligent systems.

Automatic CPAP: Bench testing

Rigau et al. Chest 2006;130; 350-361
CPAP in the treatment of sleep apnea. Fixed and intelligent systems.

Automatic CPAP: Bench testing

Rigau et al. Chest 2006;130; 350-361
The results obtained by using a variety of bench testing approaches:

Farré et al. Am J Respir Crit Care Med 2002; 166: 469-473
Lofaso et al. CHEST, 2006; 130: 343-349
Rigau et al. CHEST, 2006; 130; 350-361

coincide in showing considerable differences in the response of commercially available APAP devices.
Therefore, the conclusions derived from clinical studies carried out to date with different commercial devices should be interpreted accordingly.

It is difficult to evaluate the effectiveness of automatic CPAP if the procedure to adjust the nasal pressure is not well defined.
It seems that APAP is another example where the technological advances exceed clinical knowledge.

Indeed, current automatic CPAP devices with selectable settings provide the physician with a sophisticated tool whose clinical effectiveness is still unknown.
CPAP in the treatment of sleep apnea. Fixed and intelligent systems.

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Automatic CPAP devices can be used for two clinical applications:

To automatically treat the patient

To simplify CPAP titration:
The device automatically explores a wide range of CPAP values during the titration night and determines what is the minimum nasal pressure to normalize breathing. This application reduces costs (no PSG) and waiting lists.
**Automatic CPAP: Patient studies.**

**Application for automatic treatment**

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>nº Patients</th>
<th>Device</th>
<th>Technique</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meurice</td>
<td>1996</td>
<td>16</td>
<td>MorpheePlus</td>
<td>Apnea</td>
</tr>
<tr>
<td>Series</td>
<td>1997</td>
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<td>MorpheePlus</td>
<td>Apnea</td>
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<td>Konerman</td>
<td>1998</td>
<td>48</td>
<td>Horizon</td>
<td>Apnea+Sno</td>
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<tr>
<td>D´Ortho</td>
<td>2000</td>
<td>25</td>
<td>REM+Auto</td>
<td>Apnea+Sno</td>
</tr>
<tr>
<td>Hudgel</td>
<td>2000</td>
<td>33</td>
<td>Virtuoso</td>
<td>Sno</td>
</tr>
<tr>
<td>Teschler</td>
<td>2000</td>
<td>10</td>
<td>Autoset</td>
<td>Apnea+Sno+FL</td>
</tr>
<tr>
<td>Randerath</td>
<td>2001</td>
<td>52</td>
<td>Somnosmart</td>
<td>Impedance</td>
</tr>
<tr>
<td>Massie</td>
<td>2003</td>
<td>44</td>
<td>Autoset</td>
<td>Apnea+Sno+FL</td>
</tr>
<tr>
<td>Planes</td>
<td>2003</td>
<td>30</td>
<td>REM+Auto</td>
<td>Apnea+Snoring</td>
</tr>
</tbody>
</table>

**TOTAL** 282

Ayas NT et al. Sleep 2004; 27: 249-53
Automatic CPAP: Patient studies.

Application for automatic treatment

Ayas NT et al. Sleep 2004; 27: 249-53
CPAP in the treatment of sleep apnea. Fixed and intelligent systems.

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<th>Nº Patients</th>
<th>Device</th>
<th>Technique</th>
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</thead>
<tbody>
<tr>
<td>Resta</td>
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<tr>
<td>Noseda</td>
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<td>27</td>
<td>Malinckrodt</td>
<td>A+S+FL</td>
</tr>
<tr>
<td>Syed</td>
<td>2004</td>
<td>10</td>
<td>Virtuoso</td>
<td>S</td>
</tr>
</tbody>
</table>

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Fietze et al. Respiration 2007, in press (DOI: 10.1159/000100364)

Auto-CPAP vs. Fixed CPAP:

- no difference in AHI, ESS, compliance

- some patients prefer Auto-CPAP
Automatic CPAP: Patient studies.

**Application for CPAP titration**

**Table:**

<table>
<thead>
<tr>
<th></th>
<th>Standard (n = 107)</th>
<th>Autoadjusted (n = 106)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre-treatment</td>
<td>Post-treatment</td>
</tr>
<tr>
<td>ESS</td>
<td>15.9 (3.5)</td>
<td>7.9 (4.6)</td>
</tr>
<tr>
<td>AHI</td>
<td>61.8 (22.0)</td>
<td>5.1 (6.8)</td>
</tr>
<tr>
<td>Arousal index</td>
<td>55.2 (18.0)</td>
<td>12.3 (10.0)</td>
</tr>
<tr>
<td>Light sleep, %</td>
<td>77.3 (12.1)</td>
<td>61.3 (15.6)</td>
</tr>
<tr>
<td>Deep sleep, %</td>
<td>8.5 (9.0)</td>
<td>18.3 (12.5)</td>
</tr>
<tr>
<td>REM sleep, %</td>
<td>14.1 (6.6)</td>
<td>20.2 (7.2)</td>
</tr>
<tr>
<td>SaO2 &lt;90% of TST</td>
<td>25.3 (25.0)</td>
<td>3.0 (13.9)</td>
</tr>
<tr>
<td>CPAP pressure, cm H2O</td>
<td>8.8 (1.9)</td>
<td></td>
</tr>
<tr>
<td>CPAP use, h/d</td>
<td>5.2 (2.0)</td>
<td></td>
</tr>
</tbody>
</table>

**Figure 1:** Individual and mean CPAP levels in 20 patients with SAHS assessed by full PSG and auto-CPAP.

**References:**

Lloberes et al. 1996; Am J Respir Crit Care Med 154: 1755-8

Masa et al. 2004; Am J Respir Crit Care Med 170: 1218-2

Nolan et al. Sleep 2007, 30: 189-94:
APAP and CPAP are equally effective in managing patients with mild to moderate OSAS, but device preference may be influenced by fixed pressure requirements.
Positive Pressure Therapy
A Perspective on Evidence-based Outcomes and Methods of Application

Mark H. Sanders¹, Josep M. Montserrat², Ramon Farré³,⁴, and Rachel J. Givelber¹


Principles of CPAP and auto-adjusting CPAP devices

Breathe  |  October 2008  |  Volume 5  |  No 1
CONCLUSIONS

1. OSA is caused by recurrent static or dynamic obstructions caused by increased upper airway collapsibility.
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1. OSA is caused by recurrent static or dynamic obstructions caused by increased upper airway collapsibility.


3. CPAP is well tolerated and very effective. It is the main treatment employed to avoid sleep breathing disturbances and their consequences in OSA.
4. Alternative techniques to fixed-CPAP have been proposed to optimize the treatment (non-constant pressure, bilevel pressure, automatic CPAP).
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5. Automatic CPAP technology is at present not well defined and the commercially available devices exhibit considerable differences.
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5. Automatic CPAP technology is at present not well defined and the commercially available devices exhibit considerable differences.

6. Automatic CPAP devices are designed to simplify titration and/or to automatically treat the patient at home.
7. Automatic CPAP devices are useful to simplify titration. They allow to determine the patient’s optimal CPAP, reducing costs and waiting lists. However, it is not always applicable. ‘Difficult’ patients require conventional titration by full PSG.
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8. There are no data clearly showing that automatic CPAP is better than fixed-CPAP for the home treatment of the general OSA population. Future studies should be addressed to ascertain whether this more expensive technology is useful for a selected subpopulation of OSA patients.