Positive Airway Pressure Therapy of Obstructive Sleep Apnea

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Obstructive sleep apnea (OSA) is a common disorder characterized by repetitive collapse of the pharynx during sleep, necessitating recurrent awakenings to reestablish upper airway patency.¹ The Wisconsin Sleep Cohort Study evaluated working age adults and estimated an OSA prevalence of 4% among men and 2% among women, using a definition that required both an apnea/hypopnea index (AHI) of \( \geq 5 \) and symptoms of OSA. Employing a broader definition to include an AHI of \( \geq 5 \) with or without symptoms, they observed a prevalence of 9% among women and 24% among men.² Prevalence of Sleep-disordered Breathing in Middle-aged Korean Men and Women (AHI = 5) was 27% in men and 16% in women.³ When OSA was defined by an AHI = 5 plus excessive daytime sleepiness, its prevalence was 4.5% in men and 3.2% in women.³

OSA is considered as a risk factor for cardiovascular and cerebrovascular disorders such as hypertension, congestive heart failure, myocardial infarction, and stroke⁴ and is also associated with impaired cognitive function and alertness which contribute to the increased rates of motor vehicle accidents.⁵,⁶ Because continuous positive airway pressure (CPAP) is extremely effective in eliminating pharyngeal collapse, improves symptoms, and may reduce cardiovascular sequelae, diagnosis and effective treatment of these patients has important individual as well as public health benefits.⁷ This review focuses on OSAS treatment with positive airway pressure.

Mechanisms of continuous positive airway pressure

Sullivan and co-worker showed CPAP as a treatment for OSA in adults in 1981.¹⁰ Pharyngeal airway collapse occurs when intraluminal pressure is less than the pressure required to keep it from closing (i.e., critical closing pressure). CPAP serves to raise intraluminal pressure such that even a very collapsible pharynx (i.e., one with a very positive critical closing pressure) will maintain patency. Mechanical splinting of the upper airway has been considered as the dominant mechanism of action. An increased functional residual capacity and decreased upper
Indications for continuous positive airway pressure

The American Academy of Sleep Medicine guidelines for CPAP therapy recommend its use not only for moderate to severe OSA but also even for mild OSA, and also recommend for improving self-reported sleepiness and quality life in patients with OSA. CPAP is also recommended as an adjunctive therapy to lower blood pressure in hypertensive patients with OSA. In other group CPAP therapy has been recommended that all symptomatic patients with OSA (who by definition have an AHI of 5) should receive treatment.

Efficacy of CPAP therapy

CPAP treatment have been shown to experience a reduction in subjective as well as objective measures of daytime sleepiness and have been demonstrated to improve quality of life in symptomatic patients with even mild OSA. CPAP use has clearly been shown to have a favorable impact on daytime sleepiness in sleepy patients with OSA, driving performance as measured by driving simulators, and also accident rates. In addition, even 34 hours per night of CPAP use can improve measures of cognition and daytime vigilance.

The risk for hypertension engendered by OSA is increasingly acknowledged but the impact of PAP on hypertension remains controversial. Cheyne-Stoke breathing (CSB) is an independent predictor of mortality from congestive heart failure. CPAP has been shown to eliminate CSB and decrease mortality in patients with this pattern of periodic breathing. OSA has been associated with increased levels of soluble cell adhesion molecules which are correlated with atherosclerosis which could contribute to the increased cardiovascular and cerebrovascular morbidity associated with OSAS, but there was a trend towards increased vasodilatation following CPAP treatment.

Optimal CPAP for the treatment of OSA

The optimal prescription for positive airway pressure therapy in a patient with OSA is that which most effectively prevents the adverse consequences of OSA, while causing the least patient discomfort and the lowest risk of complications. When a decision is made to prescribe CPAP, the patient and physician both need to understand the consequences of OSA that are being addressed with this prescription. Having selected target consequences for a given patient, the clinician must translate them into measurable treatment goals. To be practical these treatment goals should include both clinical and physiological parameters.

Clinical goals are required because physiological parameters may not be totally predictive of clinical success because factors such as body position, nasal congestion, alcohol use and difference between the sleep lab and the patient's home erode the predictive value of the physiological goals. The physiological goals can be assessed at the time of CPAP titration and will allow the clinician to predict how successful a given level of CPAP will eliminate target consequences in that individual patient.

A central element of the CPAP prescription is the pressure level, which is typically derived through a titration study. The CPAP pressure is gradually increased eliminating apneas and hypopneas first, then snoring and all other respiratory effort-related arousals in all body positions and sleep stages.

Even after apneas, hypopneas and snoring are eliminated there is persistence of inspiratory flow limitation and elevated esophageal pressure which has the highest sensitivity for detecting residual upper airway obstruction. Inspiratory flow limitation is the parameter that correlates best with excessive esophageal pressure swings. Then Titration to eliminate inspiratory flow limitation can yield a pressure that is possibly more successful than CPAP, at
a pressure-level based on titration to eliminate apnea, hypopnea, and snoring.24

In an individual patient though, optimal CPAP is a moving target. This pressure is likely to decrease with chronic CPAP use and to increase with factors outside of the sleep laboratory such as weight gain, nasal congestion, change in body position, or alcohol use.25,26 As such, a highly accurate determination of optimal CPAP pressure at the time of titration may result in either over or undertreatment. To avoid either of these situations the clinician must follow up with the patient to reassess the course of the CPAP treatment and change the CPAP prescription if treatment goals are not being met.

**Compliance with CPAP therapy**

Despite the potential advantages of nasal CPAP in OSA, discomfort from the facial mask, the air pressure, and nasal symptoms often limit the extent to which patients are willing to use this therapy. Between 4.5% and 50% of patients refuse CPAP after a single night’s use in the laboratory and another 20% stop treatment primarily because of lack of benefit.27 Estimates from various studies suggest that, on average, patients use the treatment only 4 to 5 hours per night.28

The adverse effects of CPAP have been well recognized (Table 1).29 Management strategies for CPAP adverse effects include (i) good mask fit from a wide selection of commercially available types and protective covering for skin abrasion and eye discomfort (use eye patch if necessary), (ii) topical nasal spray and heated humidification for nasal symptoms and throat dryness which are common complaint, (iii) chin strap, heated humidification and orofacial mask for mask leak and upper airway dryness, (iv) pressure ramp, autotitrating positive airway pressure and bilevel positive airway pressure for pressure related problems, (v) placing device further from bed, using longer tubing and newer interface for noise intolerance, and (vi) education and support for poor motivation/disorder perception.

**Table 1. Side effects of nasal continuous positive airway pressure**

<table>
<thead>
<tr>
<th>Problem</th>
<th>Management Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mask related</td>
<td>• Optimize mask fit from wide selection of commercially available types of masks, select nonallergenic material</td>
</tr>
<tr>
<td>Skin abrasion or rash</td>
<td>• Protective skin covering</td>
</tr>
<tr>
<td>Conjunctivitis from air leak</td>
<td>• Customized mask</td>
</tr>
<tr>
<td>Pressure or airflow related</td>
<td>• Reinforce hygienic care of device</td>
</tr>
<tr>
<td>Chest discomfort</td>
<td>• Eye patch</td>
</tr>
<tr>
<td>Acrophagia</td>
<td>• Pressure lamp</td>
</tr>
<tr>
<td>Sinus discomfort</td>
<td>• Reduce pressure with bilevel positive airway pressure</td>
</tr>
<tr>
<td>Smothering sensation</td>
<td>• Try to reduce requisite pressure using oral appliance + CPAP</td>
</tr>
<tr>
<td>Difficulty exhaling</td>
<td></td>
</tr>
<tr>
<td>Difficulty initiating and/or maintaining sleep</td>
<td></td>
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<tr>
<td>Pneumothorax or pneumomediastinum</td>
<td></td>
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<tr>
<td>Pneumoencephalus</td>
<td></td>
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<tr>
<td>Problem relate to the nasal route</td>
<td></td>
</tr>
<tr>
<td>Rhinorrhea</td>
<td>• Heated humidification</td>
</tr>
<tr>
<td>Nasal congestion, nasal or oral dryness</td>
<td>• Saline nasal spray</td>
</tr>
<tr>
<td>Epistaxis (may be massive, especially in anticoagulated patients)</td>
<td>• Topical nasal steroid preparation</td>
</tr>
<tr>
<td>Noise</td>
<td>• Consider trial of nasal aerosol of ipratropium bromide solution</td>
</tr>
<tr>
<td>Cumbersoness or inconvenience</td>
<td>• Chin strap for oral dryness</td>
</tr>
<tr>
<td>Spousal intolerance</td>
<td>• Desensitization over time</td>
</tr>
<tr>
<td>Other</td>
<td>• Oronasal mask interface</td>
</tr>
<tr>
<td>Longer tubing to move device further from bedside</td>
<td>• Longer tubing to move device further from bedside</td>
</tr>
<tr>
<td>Intensifyeducation of patient and spouse</td>
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</tr>
<tr>
<td>Recommend attending a patient support grout (A.W.A.K.E Network of the American Sleep Apnea Association)</td>
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</table>

**Alternative positive airway pressure modalities**

**Autotitrating positive airway pressure (APAP)**

The current practice is to perform CPAP titration in the laboratory with a full polysomnography (PSG). A number of APAP devices are commercially available. They monitor different parameters to detect breathing events and
utilize a variety of algorithms to determine when and how much to increase or decrease pressure. In general the devices measure one or more of the following: snoring (airway vibration), airflow reductions (apnea or hypopnea), and the flow vs. time profile (airflow limitation). Recently, devices using the forced oscillation technique to monitor impedance have been developed. Most devices start with a low baseline pressure (usually 3-4 cm H2O) and then increase pressure, as needed. An absence of monitored events prompts a gradual pressure decrease. This approach provides the minimum effective pressure needed to maintain airway patency as circumstances change (e.g., body position, or appearance of REM sleep).

The potential advantages of APAP over fixed pressure CPAP are (i) that it eliminates the need for a CPAP calibration night; but the cost-effectiveness of eliminating the need for a CPAP calibration night has not been established, (ii) that it eliminates the need for future recalibration of CPAP, and (iii) that it improves CPAP compliance since the pressure rises and falls to deliver the minimum pressure required to keep the airway patent and hence lower mean pressures throughout the night. The following issues need to be considered (i) the opportunity to increase a patient's acceptance and compliance through interaction with a technician is less, (ii) it is unsafe for patients with respiratory failure or cardiac disease because of the risk of prolonged central apneas or hypoventilation accompanied by excessive hypoxemia and arrhythmias, (iii) severe mask leakage interfering with autotitration may not be recognized unless this is monitored, and (iv) the need for full PSG in the event of failed APAP therapy. This would imply added cost to the patient if purchase of the APAP device has already occurred.

The American Academy of Sleep Medicine does not support (i) the use of unattended APAP to either initially determine pressures for fixed CPAP or for self-adjusting APAP treatment in CPAP-naive patients, (ii) APAP titration or APAP treatment for patients with congestive cardiac failure, lung disease such as chronic obstructive pulmonary disease, and nocturnal arterial oxyhemoglobin desaturation due to conditions other than OSA, and for patients who do not snore (either due to palate surgery or naturally) because APAP devices relies on vibration or sound in the device's algorithm, and (iii) the use of APAP devices for split-night studies. It recommends that (i) certain APAP devices may be used during attended titration to identify by PSG, a single pressure for use with standard CPAP for treatment of OSA, (ii) once an initial successful CPAP or APAP titration has been determined by PSG, certain APAP devices may be used in the self-adjusting mode for unattended treatment of patients with OSA, (iii) patients being treated with fixed CPAP on the basis of APAP titration or being treated with APAP must be followed to determine treatment effectiveness and safety, and (iv) a re-evaluation and, if necessary, a standard attended CPAP titration should be performed if symptoms do not resolve or the CPAP or APAP treatment otherwise appears to lack efficacy.

Bilevel positive airway pressure (BPAP)

During sleep, airway resistance and the propensity for airway closure are greater during inspiration compared to expiration. BPAP allows independent inspiratory and expiratory pressure adjustments so that the patient expires against a lower pressure. The American Academy of Sleep Medicine recommends that (i) BPAP is an optional therapy in some cases where high pressure is needed and the patient experiences difficulty exhaling against a fixed pressure or coexisting central hypoventilation is present and (ii) BPAP may be useful in treating some forms of restrictive lung disease or hypoventilation syndromes associated with daytime hypercapnia.

Conclusions

Despite the prevalence of OSA, no ideal therapy has emerged to date. CPAP is currently the treatment of choice for OSA. There is good evidence supporting the use of CPAP to treat not only moderate to severe OSA but also even in mild OSA. Unfortunately, many patients are not
willing or able to tolerate CPAP therapy. There are continuous improvement strategies, such as reinforced education support. Alternative therapies such as APAP or BPAP may benefit specific subgroups of patients. Although positive airway pressure remains an imperfect intervention, it has continued to evolve and improve such that patients who would not have been able to use this therapy even in the recent past can benefit from it today.

REFERENCES


