Treatment of Obstructive Sleep Apnea

Choosing the Best Positive Airway Pressure Device

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KEYWORDS

• CPAP • Bilevel PAP (BPAP) • AutoPAP (APAP) • AutoBPAP • Expiratory pressure relief • Humidification • Adherence

KEY POINTS

- Continuous positive airway pressure (CPAP), autotitrating positive airway pressure (APAP), and bilevel positive airway pressure (BPAP) are all reasonable therapies that can be used for patients with uncomplicated obstructive sleep apnea (OSA) across the spectrum of disease severity.
- All of these therapies can be expected to reduce or resolve sleep-disordered breathing and improve symptoms of daytime sleepiness, with the best outcomes being observed in patients with moderate to severe OSA.
- Unattended APAP, either as chronic treatment or as a method to determine a fixed CPAP setting, should be considered first-line therapy for patients with uncomplicated OSA.
- BPAP should be considered for patients who are nonadherent to CPAP or APAP therapy because of pressure intolerance.
- Other factors that should be considered when choosing a PAP device for a given patient include cost, access to online data management software and patient portals, additional technologies such as heated humidification and expiratory pressure relief, and ease of portability for patients who travel frequently.

INTRODUCTION

Treatment with positive airway pressure (PAP) remains the primary therapy for most patients with obstructive sleep apnea (OSA), especially those with moderate to severe OSA. This article focuses on how to determine which type of PAP device may be best for treating a given patient or patient population with OSA. Initially, the author reviews the various forms of PAP therapy for the treatment of OSA, including continuous positive airway pressure (CPAP), autotitrating positive airway pressure (APAP), and bilevel positive airway pressure (BPAP) therapies, focusing on their mechanisms of action and indications for use in clinical practice. The remainder of the article focuses on how to determine the best PAP device for a given patient or patient population, evaluating factors such as expected outcomes, ease of use and cost of therapy, application of additional technologies, online data management, patient portals and application-based interfaces and compatibility with other manufacturers interfaces and supplies. This review focuses on types of PAP delivery systems and associated technologies and does

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not make recommendations based on a specific manufacturer because it is not clear from the literature that any one manufacturer's devices are consistently superior. Finally, this article only briefly covers interventions that may improve adherence to therapy and various mask interfaces, because these topics will be covered in depth within their own dedicated articles within this issue.

TYPES OF POSITIVE AIRWAY PRESSURE DEVICES

Once the clinician has determined that PAP therapy is the best choice for a given patient with OSA, they initially need to decide which type of PAP technology to use, because there are several modes in which PAP therapy can be delivered. These modes include CPAP, APAP, BPAP, and Auto-BPAP.

Continuous Positive Airway Pressure

CPAP therapy was initially described as a treatment of OSA by Sullivan and colleagues[1] in 1981. Since its initial description, CPAP has become the predominant therapy for the treatment of patients with OSA, because it has been demonstrated to resolve sleep-disordered breathing events and improve several clinical outcomes.[2,3] CPAP delivers a single pressure to the posterior pharynx throughout the night and acts as a pneumatic splint that maintains the patency of the upper airway in a dose-dependent fashion. The best pressure for CPAP treatment is typically determined during an in-laboratory attended sleep study, although a fixed CPAP pressure may also be determined using a short unattended trial of APAP therapy. Treatment with CPAP is typically indicated for patients with moderate to severe OSA (Apnea Hypopnea Index [AHI] $\geq$15 events per hour) with or without associated symptoms or comorbid diseases, and for patients with mild OSA (AHI $\geq$5 to $\leq$14 events per hour) with associated symptoms or comorbid diseases (**Box 1**).

Box 1
Typical indications for positive airway pressure therapies for obstructive sleep apnea

- CPAP
  - Moderate to severe OSA ($\geq$15 events per hour of sleep) with or without associated symptoms or comorbid diseases
  - Mild OSA ($\geq$5 to $\leq$14 events per hour of sleep) *with* symptoms or associated comorbid diseases:
    - Symptoms:
      - Excessive daytime sleepiness, impaired cognition, mood disorders or insomnia
    - Comorbid diseases:
      - Hypertension, ischemic heart disease, or history of stroke
- APAP
  - Moderate to severe uncomplicated OSA
  - APAP should *not* be used in patients with complicated OSA
    - Complicated OSA is defined as OSA associated with comorbid medical conditions that could potentially affect their respiratory patterns during sleep, including (1) CHF; (2) Lung diseases such as COPD; and (3) Patients expected to have nocturnal arterial oxyhemoglobin desaturation because of conditions other than OSA (eg, obesity hypoventilation syndrome and other hypoventilation syndromes).
  - May be used in an unattended setting for as the exclusive initial and ongoing therapy
  - May also be used as initial therapy to determine a fixed CPAP setting
- Bilevel PAP
  - May be used for the entire spectrum of OSA severity, although is typically considered for patients who have failed CPAP therapy or have pressure intolerance to other initial PAP therapies
- Auto-bilevel PAP
  - Role in OSA therapy and indications not clear

Autotitrating Positive Airway Pressure

APAP (also known as auto-, automated, auto-adjusting, or automatic) incorporates the ability of the PAP device to detect and respond to changes in upper airway flow or resistance in real time.[4] Currently available APAP devices use proprietary algorithms to noninvasively detect and respond to variations in patterns of upper airway inspiratory flow or resistance. Most APAP machines monitor a combination of changes in inspiratory flow patterns, including inspiratory flow limitation, snoring (indirectly measured via mask pressure vibration), reductions of airflow (hypopnea), and absence of flow (apneas), using a pneumotachograph, nasal pressure monitors, or alterations in compressor speed. Another less commonly used technology uses forced oscillation technique (FOT), which is

an alternative process that detects changes in patterns of upper airway resistance or impedance.[5–7] Because the FOT method measures changes in upper airway resistance that are independent of patient activity and ventilatory effort, this technology tends to be superior to the flow-based technology at differentiating central apneas from obstructive apneas or mask leak.

Once upper airway flow or impedance changes have been detected, the APAP devices use proprietary algorithms to automatically increase the pressure until the flow or resistance has been normalized. Once a therapeutic pressure has been achieved, the APAP devices typically reduce pressure until flow limitation or increases in airway resistance resume. Most devices have a therapeutic pressure range between 4 cm H_2O and 20 cm H_2O, providing the clinician with the ability to adjust the upper and lower pressure limits based on the clinical conditions and the patient's response to therapy. APAP should be differentiated from BPAP or auto-BPAP (discussed later) in which a separate inspiratory positive airway pressure (IPAP) and expiratory positive airway pressure (EPAP) are set with changes in pressure occurring across each respiratory cycle.

Currently available APAP machines have several potential limitations. Most flow/pressure-based APAP devices are somewhat limited in their ability to distinguish between central and obstructive apneas as well as large mask leaks.[8–11] These flow patterns are "interpreted" by these types of devices as an absence of flow, which, in the cases of central apneas and leaks, may erroneously lead to increases in pressure and worsening of the central events or leaks. Newer APAP algorithms appear to be better at differentiating obstructive from central events as well as compensating for large mask leaks. Also the ability of the APAP devices to respond to sustained hypoventilation in the absence of upper airway obstruction is unclear, because most APAP studies have excluded patients at high risk for hypoventilation, including those patients with obesity hypoventilation syndrome or chronic respiratory diseases.[7,12–21] Given these potential limitations in technology as well as the exclusion of patients with many comorbid diseases from the randomized trials comparing APAP to in-laboratory titrated CPAP therapy, APAP devices are typically recommended for patients with uncomplicated moderate to severe OSA.[13,14,22,23] APAP devices can also be used for patients with mild OSA, although there are less data to support the use of APAP in this patient population.[19] APAP devices typically should *not* be used in patients with comorbid medical conditions that could potentially affect their respiratory patterns (complicated OSA) during sleep, including the following: (1) Congestive heart failure (CHF); (2) Lung diseases such as chronic obstructive pulmonary disease (COPD); and (3) patients expected to have nocturnal arterial oxyhemoglobin desaturation due to conditions other than OSA (eg, obesity hypoventilation syndrome and other hypoventilation syndromes). Patients who do not snore (either due to palatal surgery or naturally) should not be titrated with an APAP device that relies on vibration or sound in the device's algorithm.[13,14,22] Finally, APAP devices are not recommended for split-night titrations given the lack of data to support such a practice (see **Box 1**).

Bilevel Positive Airway Pressure

BPAP therapy's potential benefits in treating patients with OSA were first described in 1990.[24] As opposed to CPAP, which delivers a fixed pressure throughout the respiratory cycle, BPAP therapy allows the independent adjustment of the EPAP and the IPAP. In its initial description, BPAP therapy demonstrated that obstructive events could be eliminated at a lower EPAP compared with conventional CPAP pressures.[24] For patients with uncomplicated OSA, BPAP is typically used in the spontaneous mode (ie, without a back up rate) with an IPAP and EPAP pressure difference of $\geq$4 cm H_2O. To determine the optimal IPAP and EPAP settings, BPAP therapy is typically titrated during an attended in-laboratory sleep study. BPAP may be used for patients with OSA across the spectrum of disease severity, although it is typically recommended as a treatment option for patients with pressure complaints that make it difficult to tolerate CPAP therapy (see **Box 1**). Although intuitively one would predict that BPAP would increase adherence by reducing expiratory pressure–related discomfort and side effects, there are in fact no objective outcomes studies that show that BPAP therapy improves adherence when compared with CPAP therapy for patients with uncomplicated OSA.[25–27] Overall, there have been few studies that objectively evaluate BPAP therapy for the treatment of OSA or compared this mode of PAP therapy to other types of PAP devices for uncomplicated OSA. In addition, there are no short-term or long-term studies evaluating the effects of BPAP on any cardiovascular outcomes in patients with uncomplicated OSA.

Auto-Bilevel Positive Airway Pressure

Auto-BPAP therapy has also been developed, which, using proprietary algorithms, automatically

adjusts both the EPAP and the IPAP in response to sleep-disordered breathing events. Limited data indicate that, compared with CPAP, auto-BPAP therapy results in similar compliance and other important outcomes in patients who have had poor initial experiences with CPAP therapy.[28,29] There is currently no peer-reviewed literature evaluating outcomes with auto-BPAP therapy for OSA in PAP-naive patients. Thus, unlike other modes of PAP therapy, there are no specific indications for auto-BPAP use, and no recommendations can be made for auto-BPAP therapy for treating patients with OSA.

CHOOSING THE BEST DEVICE BASED ON EXPECTED OUTCOMES

When determining the best PAP device for a given patient with OSA, the clinician should have a reasonable understanding of which outcomes are most important to the patient and which outcomes are most likely to improve based on the patient's symptoms and comorbid medical problems. Although it is the perception of many non–sleep practitioners and the lay public that PAP treatment consistently resolves or improves several important outcomes including sleep architecture, daytime sleepiness, neurocognitive function, mood, quality of life, and cardiovascular disease in all patients with OSA, this is not the case for many patients.

Resolution of Sleep-Disordered Breathing Events

When titrated appropriately, all types of PAP devices resolve most sleep-disordered breathing across the spectrum of disease severity and have been demonstrated to be superior to placebo, conservative management, and positional therapy with regard to this outcome.[25,26] Randomized controlled trials have also shown CPAP therapy to be superior to placebo at increasing the percent and total time in stages N3 (non–rapid eye movement sleep stage 3) and rapid eye movement (REM) sleep. CPAP's effects on other sleep parameters, including stages N1 and N2 sleep (non–rapid eye movement sleep stages 1 and 2, respectively), total sleep time, and the arousal index, have been inconsistent across studies.[25,26] Compared with standard fixed CPAP therapy, APAP devices as a group are almost always associated with a reduction in mean pressure across a night of therapy in the range of 2 cm H_2O to 2.5 cm H_2O, although peak pressures through the night tend to be higher than fixed CPAP therapy. Despite these differences between CPAP and APAP, there are no clinically significant differences between CPAP and APAP with regards to important outcomes, such as improvements in daytime sleepiness or adherence to therapy.

Improvement in Daytime Sleepiness

All of the described PAP therapies typically result in significant improvements in subjective symptoms of daytime sleepiness in OSA patients who suffer from this complaint, with the best outcomes being observed in those who suffer from moderate to severe OSA (AHI >15 events per hour).[7,12,15,16,18,19,21,30–51] The minimal and optimal amounts of nocturnal use necessary to improve symptoms of daytime sleepiness are not well defined and appear to be specific to the given individual. Even partial nocturnal use (as little as 2 hours per night) has been associated with significant improvements in daytime symptoms in some patients.[52,53] In general, greater adherence to any of the described PAP therapies on a nightly basis has been associated with greater improvements in symptoms of daytime sleepiness. The data regarding the effects of PAP on more objective measures of daytime sleepiness are more inconsistent across the spectrum of disease severity with results being similar between the different modes of therapy.[21,25,30]

Improvement in Neurocognitive Function, Mood, and Quality of Life

Numerous studies have assessed the effects of sleep-disordered breathing on neurocognitive functioning, mood, and quality of life.[26,37,54–65] Most randomized controlled studies demonstrate inconsistent improvements in several neurobehavioral performance parameters across the spectrum of disease severity.[25,37,39,54–56,66,67] The data regarding the therapeutic effects of PAP treatment on mood and quality of life are also variable and inconsistent, with many randomized trials demonstrating no clear benefits of CPAP therapy compared with placebo or conservative treatments in these parameters.[25,68] Although it is beyond the scope of this article, there are several potential explanations for the inconsistent improvements in neurocognitive function, mood, and quality of life demonstrated with CPAP therapy.[69]

Despite the inconsistent data regarding improvements in neurocognitive function with PAP use, several observational studies support a significant reduction in the incidence of motor vehicle accidents in symptomatic patients with OSA following the initiation of CPAP therapy.[70,71] Although the actual time course to improved driving performance in real-life situations is not

clear, driving simulator performance can improve in as little as 2 to 7 nights of therapy. Similar to other aspects of neurobehavioral performance that may be adversely affected by OSA, many patients with OSA may continue to demonstrate impaired driving simulator performance despite several months of high adherence to CPAP therapy.[72] Unfortunately, there is no specific threshold of CPAP use or duration of treatment that can accurately predict a given individual's fitness to safely drive a vehicle. Because the severity of OSA alone is not a reliable predictor of motor vehicle accident risk, the clinician must take into account several factors including improvements in subjective symptoms and adherence with therapy before determining a driver's ability to safely operate a motor vehicle. Although it is likely that all types of PAP therapies for OSA result in a reduction of motor vehicle accidents, all of the literature on this topic is specific to CPAP therapy.

Reductions in Hypertension and Cardiovascular Disease

Although untreated OSA has been associated with an increased risk for hypertension and other cardiovascular diseases in certain populations, the literature and outcomes data supporting the beneficial effects of CPAP on cardiovascular outcomes have been inconsistent.[25,26,73–75] Several randomized clinical trials and meta-analyses have assessed the effects of CPAP on blood pressure.[76–79] Overall, CPAP treatment appears to attenuate the adverse effects of untreated OSA on daytime and nocturnal systolic and diastolic blood pressure, and 24-hour mean blood pressure. These data demonstrate that, compared with placebo, sham CPAP, or supportive therapy alone, CPAP treatment is associated with small (−1.8 to −3.0 mm Hg), but statistically significant, improvements in diurnal mean arterial systolic and diastolic blood pressures. In patients with resistant hypertension and OSA, CPAP tends to improve nighttime blood pressure, although the impact of CPAP on daytime blood pressure has been more unpredictable.[80,81] In general, improvements in blood pressure with CPAP therapy have been associated with greater severity of baseline OSA (higher AHI), the presence of subjective daytime sleepiness, younger age, uncontrolled hypertension at baseline, and greater adherence with CPAP use on a nightly basis.

The most convincing long-term data regarding the potential beneficial effects of CPAP therapy on cardiovascular outcomes comes are based on prospective observational data in a large group of male OSA patients with the spectrum of OSA severity and associated daytime sleepiness.[82] Results from this study demonstrated that CPAP treatment (>4 hours per night) in patients with severe OSA (AHI $\geq$30 events per hour) reduced the incidence of adverse cardiovascular outcomes and improved survival, demonstrating outcomes similar to normal controls. Similar improvements in outcomes with CPAP therapy were not observed in OSA patients with mild to moderate obstructive sleep apnea. Aside from these observational data, there are little data that demonstrate that CPAP therapy as typically used reduces mortality or cardiovascular morbidity and no data that demonstrates that CPAP improves cardiovascular outcomes in patients without associated daytime sleepiness.[75,83]

The role of CPAP therapy in resolving or reducing the occurrence or reoccurrence of cardiac arrhythmias is also uncertain. Several observational studies have demonstrated an association between OSA and atrial fibrillation as well as a higher risk of recurrence of atrial fibrillation after electrical cardioversion or catheter ablation therapy. These studies also have shown an association between increased adherence with CPAP therapy and a lower recurrence rate of atrial fibrillation after these procedures.[84–87] Because all of the current data regarding CPAP therapy and atrial fibrillation are based on observational studies, the role of CPAP as an adjunct treatment to improve atrial arrhythmia control remains uncertain. Although there may be an increased risk of ventricular arrhythmias (tachycardia and fibrillation) in some patients with untreated OSA, there are limited data evaluating the effect of PAP therapy for reducing the incidence and prevalence of these events.[88] Thus, the role of PAP therapy for reducing ventricular arrhythmias in patients with OSA is not clear. As is the case with most of the cardiovascular outcomes literature, the data evaluating the effects of PAP therapy on arrhythmia reduction is specific to CPAP therapy because there are no trials looking at the effects of APAP or BPAP on these outcomes.

Given the inconclusive nature of CPAP therapy on cardiovascular outcomes in general, CPAP therapy should be considered adjunctive therapy to lower blood pressure in hypertensive patients with OSA and daytime symptoms.[26] Several authorities and professional societies have recommended that further supporting data are required to better determine the role of CPAP therapy on improving cardiovascular outcomes before making recommendations for its use in various populations.[73,74] Finally, it should be noted that all of the cardiovascular outcomes data are specific to CPAP therapy. There are no short-term or long-term randomized controlled or prospective

observational studies specifically focusing on the impact of APAP, BPAP, or auto-BPAP therapies on any cardiovascular outcomes.

POSITIVE AIRWAY PRESSURE USE AND OUTCOMES IN SPECIFIC PATIENT POPULATIONS

Most of the outcomes literature related to PAP therapy has focused predominantly on patients with moderate to severe OSA with associated daytime sleepiness and the absence of comorbid medical problems. As all clinicians know, patients with OSA may present with different phenotypes often exhibiting many different symptoms, with or without the presence of one or more comorbid medical conditions.

Positive Airway Pressure Therapy in Patients with Mild Obstructive Sleep Apnea

As noted previously, most of the literature assessing the effects of PAP on various outcomes has predominantly evaluated OSA patients with moderate to severe disease. Although approximately 28% of patients with mild disease (AHI = 5–14 events per hour) complain of subjective daytime sleepiness,[89] it remains unclear whether treating this group of patients with PAP therapy consistently improves their daytime symptoms. Results from the CPAP Apnea Trial North American Program Trial demonstrated that CPAP therapy significantly improved daytime symptoms as measured by the Functional Outcomes of Sleep Questionnaire (FOSQ) when compared with sham CPAP therapy in symptomatic patients (Mean Epworth Sleepiness Scale score of 15) with mild to moderate OSA over an 8-week period of follow-up.[90] Alternatively, The Apnea Positive Pressure Long Term Efficacy Study showed no significant improvements in objective alertness or subjective sleepiness in patients with mild OSA after 2 and 6 months of CPAP therapy.[39] Limited data evaluating APAP therapy in this patient population have demonstrated some improvement in subjective daytime sleepiness, with results similar to CPAP.[19] Thus, the role of CPAP therapy for this indication in patients with mild disease remains unclear based on the current data.

It appears reasonable to initiate CPAP or APAP therapy in patients with mild OSA and associated daytime sleepiness, but the decision to continue chronic therapy in this patient group should be based on a positive response to therapy. For patients with mild disease without daytime symptoms, it is not clear that treating these patients is beneficial or should be recommended based on the current data.

The Role of Continuous Positive Airway Pressure Therapy in Patients with Rapid Eye Movement–Predominant Obstructive Sleep Apnea

The prevalence of REM sleep–related or REM-predominant OSA is unclear, in part because of the absence of a standard definition for this entity. This OSA variant tends to be more common in women, although it may affect adult patients of both genders across the age spectrum.[91,92] The association of this OSA variant with daytime or nighttime symptoms is not clear, but it appears that a subgroup of patients is affected. Recent studies have also indicated that REM OSA is independently associated with prevalent and incident hypertension, nondipping of nocturnal blood pressure, increased insulin resistance, and impairment of human spatial navigational memory.[93,94]

For those patients who demonstrate this phenotype of OSA and complain of daytime symptoms or nighttime sleep disturbance, it is unclear if treatment with CPAP consistently improves daytime or nighttime symptoms. Limited observational data of CPAP therapy in symptomatic patients with such REM-predominant OSA have demonstrated significant improvements in daytime sleepiness, fatigue, and functional outcomes as assessed by the FOSQ. These improvements with CPAP therapy were similar to patients with OSA not limited to REM sleep.[91] However, it should be noted, there are no randomized controlled data assessing any outcomes in this subgroup of patients, including cardiovascular disease outcomes, and there are no data evaluating the effects of other types of PAP devices in this patient population.

Obstructive Sleep Apnea and Comorbid Diseases: Congestive Heart Failure, Chronic Obstructive Pulmonary Disease, Diabetes Mellitus

CHF is a common disease with an estimated prevalence of concomitant OSA of approximately 33%. Several randomized controlled studies have assessed the effects of CPAP therapy on left ventricular ejection fraction (LVEF) in CHF patients with and without systolic dysfunction.[95] Overall, CPAP therapy has shown statistically significant improvements in LVEF in patients with OSA and concomitant systolic dysfunction, with an average improvement in LVEF across studies of approximately 5%. In patients with diastolic CHF and concomitant OSA, CPAP therapy has not been associated with significant improvements in LVEF (1%). However, it is uncertain if the improvements in LVEF in patients with OSA and concomitant CHF translate into improvements in other

important outcomes, such as reductions in hospitalizations and mortality. Most of the studies evaluating this patient population have been limited by small sample sizes and relatively short durations of follow-up (typically 12 weeks or less). These findings are limited to CPAP therapy, because APAP is contraindicated in this group of patients, and there are no data evaluating the use of BPAP in this patient population.

The "overlap syndrome" refers to the coexistence of OSA with COPD. Prospective observational data have shown that CPAP therapy in OSA patients with concomitant COPD has been associated with significant reductions in both acute exacerbations of COPD requiring hospitalizations and death with outcomes similar to COPD patients without OSA.[96] Increased adherence to CPAP therapy has been independently associated with reduced mortality in this patient population, whereas decreased CPAP adherence and increased age have been independently associated with increased mortality.[97] Observational data would suggest that adherence to CPAP therapy for as little as 2 hours per night may be associated with a reduction in mortality in this group of patients. Given the current observational data, it is reasonable to recommend CPAP therapy in patients with the overlap syndrome, although given the absence of randomized controlled data in this patient population, the role of CPAP therapy to reduce exacerbations or improve mortality remains undefined. As is the case with CHF, these recommendations are limited to CPAP therapy because APAP therapy is contraindicated in this patient population.

The role of CPAP therapy for improving important outcomes-associated diabetes mellitus (short-term and long-term glucose control) in patients with coexistent OSA is also unclear, because most of the trials evaluating the use of CPAP in this patient population have yielded inconsistent results.[98,99] The role of CPAP as an adjunct therapy to improve weight loss is also uncertain, and adequate treatment of OSA has not been observed to result in enhanced weight loss in most studies.[100] In fact, some studies have demonstrated a small, but significant weight gain with CPAP use, with greater weight gain being associated with increased adherence to CPAP therapy.[101] The role of APAP or BPAP on weight reduction is not clear.

Positive Airway Pressure in Patients Without Daytime Sleepiness

As noted previously, the presence of subjective daytime sleepiness has generally been associated with a more robust improvement in blood pressure with CPAP therapy. Several large randomized controlled trials have assessed the effect of CPAP therapy in patients with moderate to severe OSA without daytime sleepiness (Epworth Sleepiness Scale score $\leq$10) on various cardiovascular outcomes. In general, CPAP therapy has not been associated with significant improvements in blood pressure, reductions in incident hypertension, or cardiovascular events (nonfatal myocardial infarction or stroke, transient ischemic attack, CHF, or cardiovascular death) or reductions in cardiovascular morbidity or mortality in patients with previously diagnosed cardiovascular diseases.[75,83,102] Thus, the benefit of treating patients with moderate to severe OSA who do not have symptoms of daytime sleepiness with any type of PAP device is unclear and remains to be better defined.

POSITIVE AIRWAY PRESSURE OUTCOMES SUMMARY

CPAP, APAP, and BPAP treatment consistently improve or resolve OSA events across the spectrum of OSA severity and improve symptoms of daytime sleepiness predominantly in patients with moderate to severe OSA. Improvements in other outcomes are less consistent. Treatment with CPAP has been associated with small reductions in blood pressure, with greater reductions being observed in patients with associated daytime sleepiness, poorly controlled or resistant hypertension, and in those who are more adherent to therapy. The role of any type of PAP therapy for reducing long-term cardiovascular risk or mortality in OSA is uncertain based on the current data. Finally, the role of any type of PAP device for patients without daytime symptoms across the spectrum of OSA severity is undefined.

ADDITIONAL QUESTIONS TO ADDRESS WHEN CHOOSING A POSITIVE AIRWAY PRESSURE DEVICE

In addition to the type of PAP delivery system and expected outcomes, there are several other issues to consider when choosing a PAP device for a given patient or patient population. Other factors that should be considered include the following: effect of PAP technology on adherence to therapy, additional options to improve comfort, cost of therapy, including the need for an in-laboratory attended polysomnography (PSG), availability of online data management tools and patient interfaces, portability, and compatibility with other manufacturers masks and supplies.

Effect of Positive Airway Pressure Technology on Adherence to Therapy

Adherence to PAP is typically defined as use ≥4 hours per night on ≥70% of the nights.[103] Using this definition, subjective adherence ranges between 65% and 90%, whereas objective measures of PAP adherence have demonstrated use in the range of 40% to 83% with the average nightly use ranging between 4 and 5 hours per night.[104] Unfortunately, there are few if any consistent predictors of short-term or long-term adherence to PAP therapy.

Given the differences in PAP delivery systems and advancements in technology over time, do any of the PAP platforms consistently result in improved adherence to PAP therapy? The short answer to the question is no. Head-to-head studies comparing APAP and BPAP to CPAP have consistently demonstrated similar adherence and improvements in daytime symptoms among the 3 types of PAP delivery modes.[21,105] Thus, the choice of device for a given individual should be based on other factors, such as symptoms, expected outcomes, cost, underlying comorbid medical problems, and other factors that are outlined in this article.

Additional Options That May Improve Positive Airway Pressure Comfort and Adherence: Heated Humidification and Expiratory Pressure Relief

Given the flow rates generated by most PAP devices, many patients complain of nasal congestion or upper airway dryness without the addition of humidification. Fortunately, most modern-day PAP devices have the capacity to add a humidification system. Although one would assume that heated humidification consistently results in improved adherence with PAP therapy, the data evaluating the effects of heated humidification on adherence to CPAP therapy remain controversial. Although there are some studies that demonstrate that the addition of heated humidification can improve adherence to CPAP therapy, there are several studies demonstrating no improvement in adherence with this intervention.[26,106–110] Patients who tend to benefit the most from the addition of heated humidification are those with symptoms of nasal congestion or rhinitis. Limited data evaluating the role of heated tubing to heated humidification have not consistently shown improvements in adherence in patients with and without nasopharyngeal complaints.[110] With this information in mind, heated humidification should be considered for most patients when initially prescribing a PAP device, given the potential benefits with little associated risks. Patients can determine the level of heated humidification depending on their symptoms and changes in their local environment.

Another common complaint for many patients with OSA who are treated with PAP therapy is the uncomfortable feeling of exhaling against positive pressure. This consequence has been proposed as one conceivable barrier to the long-term acceptance of PAP therapy. Several PAP manufacturers have developed expiratory pressure relief (EPR) systems in an attempt to remedy this potential problem. EPR device technologies allow pressure relief during exhalation with the goal to make PAP therapy more comfortable. EPR technologies briefly reduce the PAP pressure, between 1 cm H_2O and 3 cm H_2O, during exhalation before returning the pressure to its set PAP setting before the initiation of inspiration. Certain EPR technologies monitor the patient's airflow during exhalation and reduce the expiratory pressure in response to the airflow and patient effort. The amount of pressure relief varies on a breath-by-breath basis, depending on the actual patient's airflow, and is also dictated by the patient's preference setting on the device.

Although several PAP manufacturers have developed EPR technologies for the market place, only the Philips Respironics (Respironics, Inc, Murrysville, PA, USA) technology (CFLEX) has been extensively evaluated in the peer-reviewed literature.[111–113] Several randomized controlled trials have evaluated the role of CFLEX technology compared with standard CPAP therapy in patients with uncomplicated, predominantly moderate to severe OSA. Overall, the use of such CFLEX technology at fixed pressure relief settings between 1 cm H_2O and 3 cm H_2O has not been associated with improved adherence.[113] In addition, improvements in other commonly measured outcomes (subjective sleepiness, objective alertness, vigilance, or residual OSA) were similar to, but not better than, standard CPAP therapy. Similar results have been observed with a similar technology for APAP devices (AFLEX).[20,114] Despite the lack of convincing outcomes data, most of the current PAP devices have EPR or Flex technologies included as standard additions. Thus, patients should be instructed on how to adjust these technologies and may self-titrate the amount of pressure relief based on comfort.

Cost of Therapy Including the Need for an In-Laboratory Attended Polysomnography

Current general trends in US health care economics have payers focusing on reducing costs, while improving quality and value. Although the

Affordable Care Act has increased the availability of health insurance, one unfortunate result has been increased out-of-pocket costs for patients in the forms of higher deductibles and increased annual health insurance costs. Finally, as payment systems move away from fee-for-service payment models, management approaches that reduce costs while maintaining or improving quality will become more important. Thus, the clinician needs to be aware of the patient's and health system's (where appropriate) costs, when prescribing PAP therapy for the patient with OSA.

In general, CPAP devices are less expensive than APAP and BPAP devices for patients and payers. The main advantage of APAP therapy is that it can be prescribed and used in an unattended setting obviating the need and costs associated with an in-laboratory titration study. As noted previously, APAP used in the proper patient population results in similar outcomes as CPAP. Thus, when reductions in cost are considered in the management strategy for a given patient or population, APAP should be considered the initial PAP treatment either as a primary therapy or as a method to determine a fixed CPAP setting for ongoing treatment in patients with moderate to severe uncomplicated OSA.[115,116]

Availability of Online Data Management Tools and Patient Interfaces

Unfortunately, as noted previously, most studies have not been able to identify factors that consistently predict short- or long-term adherence with CPAP therapy.[32,103,117–120] Because adherence with PAP therapy tends to be suboptimal, subjective adherence tends to overestimate objective PAP use, and there are no consistent early predictors of PAP adherence, professional societies currently recommend and many payer policies require, objective adherence data assessment to document adherence with therapy and potentially identify problems that can be addressed.[3] Although most randomized controlled trials have used objective adherence data to monitor outcomes related to PAP therapy, the overall impact of assessing objective compliance data either in person or remotely via a telemedicine approach for all patients on PAP therapy is uncertain.[121,122]

Most of the PAP manufacturers have developed sophisticated online software programs for monitoring several parameters of PAP therapy, including nightly adherence, efficacy of therapy (residual AHI), and problems with mask fit (primarily amount of air leak). Many of the same manufacturers have also developed computer-based patient portals or phone-based applications that allow the patient to monitor their progress with therapy. Despite the absence of outcomes data demonstrating consistent benefits of using this information to improve adherence to therapy, the author's group finds this information invaluable for managing patients on a day-to-day basis. Factors to consider when choosing a specific manufacturer's software should include ease of use for the clinician and the patient, compatibility with a given electronic medical record system, and the ability to monitor progress and make adjustments remotely. In reality, most clinicians will need to get comfortable using more than one data-management system given the array of PAP manufacturers currently on the market.

Portability and Compatibility with Other Manufacturers Masks and Supplies

Practical issues to consider when prescribing a PAP device include the patient's occupation and travel plans as it relates to the ease of portability. Most modern-day PAP devices, regardless of delivery technology, are approximately similar in size and weight when considering the PAP device and supplies. More recently, several companies market much smaller CPAP and APAP devices that may be more suitable for patients who frequently travel for their job or leisure. It is not clear if these smaller portable PAP devices will be durable enough for everyday use. Finally, because it is common for patients to use masks made by different manufacturers, it is good to know that most current PAP devices are compatible with masks made by several manufacturers.

SUMMARY

CPAP, APAP, and BPAP all are reasonable therapies that can be used for patients with uncomplicated OSA across the spectrum of disease severity. All of these therapies can be expected to reduce or resolve sleep-disordered breathing and improve symptoms of daytime sleepiness, with the best outcomes to be expected in patients with moderate to severe OSA. Unattended APAP, either as chronic treatment or as a method to determine a fixed CPAP setting, should be considered first-line therapy for patients with uncomplicated OSA when the cost of treatment is a priority for the patient. BPAP should be considered for patients who are nonadherent to CPAP or APAP therapy because of pressure intolerance. When choosing the best PAP device for a given patient, the clinician should consider several other factors including cost of the device and management strategy, access to online data management software and patient portals, additional

technologies such as heated humidification and EPR, ease of portability for patients who travel frequently, and compatibility with other manufacturers' supplies.

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