Introduction

Obstructive Sleep Apnea (OSA) is a common medical disorder with adverse health, economic and societal impact. OSA is characterized by upper airway collapse during sleep, which causes repeated periods of breathing cessation (apneas) and blood oxygen desaturation, and results in impaired sleep quality and daytime sleepiness [1]. OSA is associated with multiple health conditions including cardiovascular disease, stroke, obesity, impaired cognitive performance, and all-cause mortality [2-5]. Moreover, untreated OSA is associated with increased risk for motor vehicle accidents, occupational accidents and reduced occupational performance [6]. Prevalence estimates for OSA vary, ranging from 9-37% of men and 4-50% of women, and have increased over the past several decades, possibly concomitant with the rise in obesity rates [1,7].

Continuous Positive Airway Pressure Treatment (CPAP) was developed in the 1980s and remains the standard of care for treating sleep apnea in adults [8,9]. CPAP eliminates respiratory events by providing pressurized air through a nasal mask and thereby preventing pharyngeal collapse. CPAP reduces the number of apneas and arousals as well as daytime sleepiness [10]. CPAP treatment has been shown to improve sleepiness and hypertension, decrease cardiovascular disease events, and reduce the direct and indirect costs of OSA [6,11,12].

Because CPAP involves the nightly application and use of a mask throughout sleep, patient adherence is notoriously problematic. Adherence rates vary greatly, but have been estimated to be 30-60% [13]. Historically, use of CPAP for 4 hours per night on 70% of nights has been used as an arbitrary criterion for defining minimally acceptable adherence [14]. However, studies have found that greater CPAP use is associated with better clinical outcomes (e.g., less daytime sleepiness, improved cognitive functioning, and reduced mortality) [14]. Understandably, adherence to CPAP remains a primary concern in the field, with much attention dedicated to efforts to improve adherence. This review provides a current update on interventions to enhance adherence to CPAP.

Factors Influencing CPAP Use

Extensive reviews of factors influencing CPAP adherence have been conducted [14-17], and thus a full review is beyond the scope of this paper. However, to understand the myriad factors impacting adherence, it is useful to conceptualize them within an integrated model. The biopsychosocial model is one such integrative framework emphasizing that biomedical, psychological and social factors interactively influence health and health behaviors. CPAP adherence, as a health behavior, readily lends itself to the biopsychosocial model [15,18]. Crawford and colleagues [15] describe how the biopsychosocial model can be applied to CPAP use specifically and argue that these biopsychosocial factors as well as their interactions should be considered to optimize interventions to enhance CPAP use.

Biomedical Factors: Biomedical factors may include patient demographic characteristics, disease characteristics and treatment-specific factors [14,15]. When applied to CPAP therapy, treatment-specific factors include CPAP technologies (i.e., pressure modality, flexible pressure settings, mask interface, humidification), surgery for nasal obstruction, and hypnotics. Studies examining interventions targeting these factors have yielded mixed results, as reviewed in the "Interventions Addressing Biomedical Factors" section below.

Psychological Factors: CPAP usage is a health behavior that requires significant changes in one’s lifestyle. From a psychological perspective, beliefs about OSA and attitudes about treatment benefits/drawbacks/outcomes have been found to influence CPAP adoption and usage, and users are generally primed to negatively view CPAP [16,17]. Motivation to use CPAP, including commitment...
Intervention type. An intervention may address factors from more than one category, and be summarized in Table 1. It is important to note that while an intervention to promote CPAP adherence is reviewed below and/or family can either positively or negatively influence CPAP usage [27]. Patient-provider communications as well as interactions with health care professionals have been found to affect adoption and maintenance of recommended health behaviors, but research is scant with respect to CPAP [16].

Interventions to Promote CPAP Adherence

Interventions addressing biomedical, psychological/behavioral and social factors affecting CPAP adherence are reviewed below and summarized in Table 1. It is important to note that while an intervention may address factors from more than one category, for the purposes of this review, it has been categorized by predominant intervention type.

Interventions Addressing Biomedical Factors

Advances in CPAP technology

a. Pressure modality: CPAP functions by delivering a continuous pressurized flow of air during inhalation and exhalation. As technology has advanced over the past several decades, additional pressure modalities such as Auto-Titrating Positive Airway Pressure (APAP), Bilevel Positive Airway Pressure (BiPAP), and Adaptive Servo-Ventilation (ASV) have been developed, with the intention of optimizing pressure requirements to improving tolerance, reduce side effects, and ultimately increase adherence.

i. Auto-Titrating Positive Airway Pressure (APAP): APAP flexibly adjusts pressure based on airway resistance, thereby providing the minimum necessary pressure to resolve respiratory events during sleep. APAP has been shown to have a statistically significant advantage in adherence over CPAP, on the magnitude of 11-14 minutes/night, although the clinical impact of such a small difference is uncertain [28-31]. Studies suggest that patients prefer APAP over CPAP [30,31].

ii. Bilevel Positive Airway Pressure (BiPAP): BiPAP is designed to improve pressure tolerance by cycling between two levels of pressure: a higher inspiratory pressure and a lower pressure upon exhalation. Studies have not shown any advantage in adherence to BiPAP compared to standard, fixed-pressure CPAP [30,32]. While there is some evidence that transitioning certain CPAP users with poor adherence to BiPAP may improve use, identifying the type of patient most likely to benefit from BiPAP remains to be elucidated [32].

iii. Adaptive Servo-Ventilation (ASV): Adaptive servo-ventilation provides ventilatory support in response to the patient’s respiration. Adherence to ASV is similar to CPAP in complex sleep apnea patients [33]. Improved adherence with ASV over CPAP has been documented in samples of sleep apnea patients with heart failure [34,35]. However, given recent findings from a large randomized controlled trial (RCT) showing increased risk of cardiovascular mortality in heart failure patients with reduced ejection fraction treated with ASV [36], ASV is contraindicated in this population.

b. Flexible pressure: Flexible pressure features (e.g., C-flex, A-flex) are designed to increase patient comfort with respect to breathing against a positive pressure and can be added to the various modes of pressure delivery. Expiratory Pressure Relief (EPR), such as C-flex, provides a decrease in pressure early in the exhalation to mitigate the common complaint from patients regarding the discomfort of exhaling against a high pressure [12]. While this feature carries obvious face validity for improving comfort, meta-analytic reviews have not borne out any advantage with EPR in enhancing adherence to CPAP [30,37].

A-flex is another flexible pressure feature that combines EPR and pressure relief at the end of inhalation. Kushida and colleagues [38] compared APAP + A-flex to standard CPAP and reported no differences in adherence at 3 or 6 months. Chihara and colleagues [39] randomly assigned patients to receive APAP, APAP + C-flex, or APAP + A-flex. At 3 months, adherence was significantly greater in patients given APAP + C-flex compared to patients using APAP without flexible pressure relief. Although the APAP + A-flex group did not have improved adherence compared to the other groups, when a subgroup of poor adherers in the APAP group were crossed over to receive APAP + A-flex, their adherence improved significantly at 6 months. Although these studies suggest that A-flex does not confer any advantage to treatment adherence, it remains to be determined whether particular subgroups of apnea patients may benefit.
c. **Mask interface:** Optimizing the CPAP mask interface to improve comfort and adherence has been a market focus in the industry since CPAP became commercially available. It is widely believed that the type of mask plays a large role in successful adherence to CPAP. Although there are dozens of different CPAP masks on the market, the majority are one of 3 types: nasal masks (covering the entire nose), nasal pillow masks (a cushion that is seated under the nostrils) or oronasal masks (covering the nose and mouth). In clinical practice, nasal masks are the standard, with nasal pillow masks presumed to be preferred by patients with claustrophobia, and oronasal masks typically selected for patients who are mouth breathers or suffer from nasal obstruction. However, research on type of mask and CPAP adherence is equivocal and studies matching patient factors with type of mask are lacking.

In a recent review article, Andrade and colleagues [40] concluded that there was no convincing evidence conferring any significant advantage to oronasal masks over nasal masks. In fact, oronasal masks have several disadvantages over nasal or nasal pillow masks. Oronasal masks may increase airway resistance (perhaps via posterior tongue displacement), resulting in more residual respiratory events, a higher effective pressure requirement, and more air leaks compared to nasal masks [40-43]. Oronasal masks are associated with poorer adherence to CPAP compared to nasal masks and nasal pillow masks, as well as increased discomfort, claustrophobia, and dissatisfaction [40,42,44]. Furthermore, by covering both the nose and the mouth, oronasal masks bear the added risk of aspiration.

Only a handful of studies have compared CPAP adherence between nasal pillow masks and nasal masks, and the findings have been inconsistent [40]. One RCT found no differences in CPAP adherence at 4 weeks in patients using nasal pillow vs. nasal masks [45], and a similarly designed study found no differences in hours of CPAP use at 3 weeks, but a significant difference in percentage of days used (patients with nasal pillow masks used CPAP approximately 2 days more during the study period than those with nasal masks) [46].

**d. Heated humidification:** The integration of heated humidifiers with CPAP, to reduce airway dryness and provide thermal comfort, has become standard for most CPAP users. The level of heat is user-controlled, and therefore flexible in adapting to different environments and comfort preferences. Few RCTs have investigated the impact of heated humidification on CPAP adherence, and the findings are mixed [12,30]. Recent studies comparing an integrated heated breathing tube to conventional CPAP humidification [47] or no humidification [48,49] have not found any significant improvement in CPAP adherence.

**Surgery**

Surgical interventions to treat sleep apnea include a variety of techniques designed to reduce airway obstruction or promote weight loss [50]. In general, surgery for sleep apnea is considered only when an individual has failed CPAP, with the goal of eliminating or significantly reducing the severity of sleep disordered breathing. In many cases, surgery fails to adequately resolve sleep apnea and the individual is faced with resuming CPAP, sometimes with the added burden of surgical complications that negatively impact CPAP adherence [50].

Some surgical procedures, however, may be considered as an adjunct to CPAP, with the goal of improving tolerance of CPAP. Procedures that target nasal obstruction (e.g., septoplasty, septrhinoplasty, turbinate reduction, endoscopic sinus surgery) can resolve the nasal symptoms that afflict many CPAP users, resulting in improved adherence and lower CPAP pressure requirements [50]. A recent meta-analysis investigating the impact of nasal surgery on CPAP found that surgery led to a reduction in therapeutic CPAP pressure (presumably by reducing nasal airway resistance) and an increase in objective CPAP use post-surgery [51]. Notably, a subgroup analysis revealed that 89% of patients who were not using CPAP prior to nasal surgery were able to use CPAP after surgery. Thus, careful evaluation of nasal symptoms in individuals with sleep apnea is critical to optimize CPAP adherence. Because nasal symptoms can occur independently, fluctuate (e.g., allergic rhinitis) and/or develop iatrogenically as a side effect of CPAP, ongoing assessment is indicated.

**Hypnotics**

Given the critical importance of a patient’s early experience with CPAP in predicting long-term adherence, the short-term use of hypnotic medications has been advocated to address anxiety and insomnia that may be associated with the transition to CPAP therapy. RCTs have yielded inconsistent findings: in one study, eszopiclone administered for the first two weeks of CPAP therapy resulted in improved CPAP adherence and less CPAP discontinuation at 6 months compared to placebo [52], but a similarly-designed study of zolpidem did not find improved CPAP adherence at one month compared to placebo or usual care [53]. Studies exploring the strategy of premedicating patients with hypnotic medications during laboratory CPAP titration polysomnography similarly have yielded conflicting results [54,55].

**Interventions Addressing Psychological and Behavioral Factors**

Psychological and behavioral interventions endeavor to promote CPAP use by modifying adherence-related beliefs, cognitions, and/or behaviors and are grounded in theoretical models (e.g., biopsychosocial model, social cognitive theory, health belief model, transtheoretical model, social learning theory, Triandis theory of behavior) [15,56,57]. These interventions have been evaluated in a meta-analysis of behavioral, educational, and supportive interventions for CPAP adherence [58]. The behavioral interventions, largely based on motivational enhancement and cognitive behavioral approaches, increased hours of CPAP use by 1.44 hours/night compared to usual care, and this improvement was larger than that detected in educational and supportive interventions (see below). Furthermore, the percentage of patients using CPAP longer than 4 hours/night increased substantially (28% to 47%) with behavioral interventions.

**Motivational Enhancement Therapy (MET)**

Motivational enhancement therapies grew from efforts to treat addictive behaviors, but have been shown to be effective in promoting health behaviors [59]. MET is a non-judgmental, patient-centered approach, wherein the therapist helps the patient verbalize and strengthen motivation for change and resolve ambivalence about behavior change. The therapist uses feedback to reinforce the patient’s commitment to change and self-efficacy (confidence in making...
Exposure therapy for claustrophobia/anxiety (compared to usual care) across the 3 month study period [72]. 6 month follow-ups [57]. In contrast, another approach combining a patient’s knowledge about the disease and its management. Several studies have investigated whether enhancing education improves CPAP adherence, using a variety of different strategies such as video recordings, telephone calls, individual or group didactic sessions, or printed information [14,58]. While an initial review showed educational interventions to be largely ineffective in promoting adherence [14], a more recent meta-analytic review concluded that such interventions are associated with a modest (36 minutes) increase in CPAP use and a greater percentage of patients who use CPAP at least 4 hours per night (from 57% to 70%) [58].

Interventions addressing Social Factors

Support

Similar to education, supportive interventions consist of a wide range of strategies and formats. These interventions are designed to provide ongoing feedback and assistance with problem-solving obstacles preventing the effective use of CPAP. In the meta-analytic by patients and often translate to poor adherence [19,20,73]. Claustrophobia entails extreme anxiety and panic elicited by situations or settings in which the individual experiences a sense of being closed in or entrapped and is composed of two “core” fears: fear of restriction and fear of suffocation [74]. Because CPAP requires the user to breathe pressurized air through a mask strapped to the head, it is not difficult to understand how this treatment may elicit fears of restriction and suffocation.

Strategists targeting CPAP-related claustrophobia have been developed on the presumption that anxiety/panic reactions to CPAP actually represent a phobic reaction based on the same learning principles as other phobias and therefore should be treatable with similar psychological interventions such as exposure therapy or systematic desensitization [75]. Exposure therapy involves developing a hierarchy of steps (ranging from least to most anxiety-provoking) related to the feared object or situation, under the guidance of a therapist. The individual is then supported in confronting the feared situations in a gradual manner, and over time, the anxiety decreases. Desensitization therapy, also based on learning theory, combines a relaxation component with the exposure hierarchy, so that anxiety experienced during exposure to the feared stimulus is replaced by feelings of relaxation.

Based on a case series study showing a significant improvement in CPAP use after exposure therapy for CPAP-related claustrophobia and a large treatment effect size [76], Means and Edinger [75] developed a CPAP-specific exposure therapy protocol designed to be delivered in ≤6 sessions over 1-3 months. To date, there have been no RCTs evaluating the effectiveness of this intervention. Similarly, desensitization therapy has not been systematically studied with CPAP-related anxiety or claustrophobia. However, given the early positive findings with exposure therapy and a study that demonstrated improved CPAP adherence with a combination of education and progressive muscle relaxation [72], desensitization therapy should be explored as a potential intervention in anxious or claustrophobic CPAP users.

Cognitive Behavioral Therapy (CBT)

CBT is a psychotherapeutic approach in which the therapist helps the patient identify and alter maladaptive thoughts and behaviors. The treatment typically involves several components and skills such as psychoeducation, self-monitoring of behaviors and/or thoughts, reinforcement and/or modeling of desired behavior, goal setting, problem-solving, relaxation exercises, and homework assignments [67]. CBT has been applied to numerous problems (e.g., depression, anxiety, insomnia), typically with therapeutic components both grounded in CBT theory and tailored to the problem at hand. CBT approaches for addressing poor CPAP adherence can be considered in their infancy, and unlike CBT for other disorders such as insomnia, there is not one standardized approach to CPAP adherence.

Bartlett [68,69] proposed a CBT model for CPAP adherence consisting of the following components: 1) psychoeducation specific to sleep apnea/CPAP; 2) a cognitive component emphasizing positive outcome expectancies and treatment beliefs; 3) partner involvement; 4) a modeling component (video recording of successful CPAP user) with directed discussion; and 5) evaluation of pros and cons of CPAP, readiness to change, motivation and confidence. In two separate randomized trials, Bartlett and colleagues [70,71] tested components of this intervention (that also included relaxation strategies) in a group format. In the first study, participants who received two one-hour group sessions showed robustly higher CPAP adherence at one week and one month compared to usual care [71]. In a more recent study, all participants received enhanced education and then were randomly assigned to receive social interaction or an abbreviated (35 minutes) CBT intervention [70]. In this context, the CBT intervention did not improve CPAP adherence.

Other investigators have also included relaxation components in their CPAP adherence intervention. One approach, combining muscle relaxation, deep breathing, music and problem solving, suggested a short-term enhancement of CPAP adherence after 1 month (compared to a placebo control) that deteriorated by 3 and 6 month follow-ups [57]. In contrast, another approach combining education with muscle relaxation found sustained CPAP adherence (compared to usual care) across the 3 month study period [72].

Exposure therapy for claustrophobia/anxiety

Claustrophobic reactions to CPAP are commonly reported
review noted above [58], the authors analyzed supportive interventions such as intensive follow-up visits, telemedicine interventions, home visits, and peer support meetings. Although the evidence was rated as low quality, the authors concluded that supportive interventions resulted in increased CPAP adherence of 49 minutes/night and a greater percentage of patients who used CPAP at least 4 hours per night (from 59% to 75%).

Historically, the role of the bed partner in facilitating or hindering CPAP adherence has been largely ignored, although its importance is gaining recognition [17,27,77]. Studies investigating the impact of factors such as marital status, bed-sharing, and relationship quality on CPAP adherence have yielded mixed findings [15]. Although poorly understood, it appears that involvement of the partner can produce positive or negative influences on CPAP adherence, suggesting an interaction that is both bidirectional and complex [27].

Telemedicine

Telemedicine, the application of electronic and communications technologies to support health, offers potential advantages to CPAP users in regard to access to care, closely monitored follow-up, and cost effectiveness. In general, studies investigating the impact of telemedicine approaches on CPAP adherence have found that they compare favorably with usual care [78-82] or may improve adherence [83,84].

Summary and Future Directions

Multiple factors affect patients’ adoption and adherence to CPAP, and these factors can be conceptualized within an integrative biopsychosocial framework, examining biomedical, psychological/behavioral and social factors [15,18]. More research is needed to examine how these factors interact in order to optimize interventions for CPAP adherence. There is a need for studies that investigate long-term adherence; CPAP is a treatment for a chronic health condition, and most studies that have been conducted to date have employed relatively short follow-up periods (6 months or less).

Most interventions focusing on biomedical factors (i.e., treatment delivery, CPAP side effects) have yield mixed results, emphasizing the need for further research into matching specific patients with specific treatment factors. Moreover, report of OSA symptoms, CPAP adherence, and amelioration of OSA symptoms may vary by race/ethnicity and socioeconomic status, highlighting the importance of studying differential factors that may impact CPAP adherence by subgroup [85-88].

Psychological/behavioral interventions have been shown to be effective in increasing motivation and reducing claustrophobia/anxiety related to CPAP use. More studies are needed to bolster these findings and to better match intervention components with patient-specific factors. As well, addressing CPAP adherence in OSA patients with comorbid insomnia remains an understudied area. With respect to social factors, the CPAP patient’s partner and/or family as well as interactions between health care professionals and the patient can have a considerable influence on CPAP use, but these factors are currently understudied.

Behavioral sleep medicine providers (typically psychologists with specialized training) can assist pulmonologists and other sleep specialists in treating patients with barriers that may interfere with CPAP adherence, thus improving quality of care and reducing costs [89]. Behavioral sleep medicine specialists can assess and treat cognitive/behavioral/social factors that affect sleep and CPAP adherence. However, there is a lack of providers trained in behavioral sleep medicine, highlighting the need for dissemination of behavioral sleep medicine practices.

In summary, sleep apnea is a prevalent disease with significant health, economic and societal burden. CPAP is an effective treatment, yet many patients struggle with adherence. Factors which influence adherence are multi-faceted and conceptualized within a framework of biomedical, psychological, behavioral, and social factors that interact and fluctuate over time. Interventions for improving adherence can be optimized within the context of a team approach.

Practice Points

1. Provide education and support during sleep apnea diagnosis and treatment, particularly in the early stages (i.e., after one week and one month)
2. When “selling” the idea of CPAP, focus on benefits of CPAP treatment, while acknowledging drawbacks/inconvenience
3. Involve the patient’s partner and/or family in planned treatment
4. Understand the perspectives and attitudes of the patient and partner/family, and work on enhancing motivation and self-confidence as well as knowledge from the outset
5. Refer to a Behavioral Sleep Medicine specialist for assistance with motivation, claustrophobia/anxiety and/or other psychosocial barriers to adherence
6. Start with nasal mask or nasal pillows; transition to oronasal mask only if needed
7. Use communications technology (telemedicine) to provide support and follow-up to individuals who may not be able to come to clinic appointments

References


