Early CPAP Use Identifies Subsequent Adherence to CPAP Therapy

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Study Objectives: To explore the relationship between specific factors such as sex and early continuous positive airway pressure (CPAP) use, and 30-day adherence to CPAP therapy.

Design and Setting: Retrospective study conducted at a single center in southeast Michigan.

Patients: One hundred patients with obstructive sleep apnea who were recently initiated on CPAP therapy with electronic adherence information relayed from the CPAP device to a laboratory-based computer through telephone modem.

Interventions: N/A.

Measurements and Results: An empiric threshold value of objective CPAP use of greater than 4 hours per night measured 3 days following CPAP initiation was predictive of level of CPAP adherence measured 30 days later. Furthermore, CPAP adherence was directly proportional to age (R = 0.25, P = .018). There were no sex-related differences in adherence to CPAP therapy.

Conclusions: Long-term adherence to CPAP therapy can be predicted as early as 3 days following CPAP initiation. The study also demonstrates that younger age and African-American race are independently associated with lower CPAP adherence.

Keywords: Sleep-related breathing disorder; obstructive sleep apnea; sleep-disordered breathing; continuous positive airway pressure; CPAP; adherence; compliance, sex, race, age

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INTRODUCTION

OBSTRUCTIVE SLEEP APNEA (OSA) IS A COMMON DISORDER AND HAS BEEN ASSOCIATED WITH AN INCREASED RISK OF ADVERSE CARDIOVASCULAR EVENTS[1] AND automobile accidents,[2] increased healthcare utilization,[3] and decreased productivity.[4] Continuous positive airway pressure (CPAP) therapy is widely considered the first-line treatment for OSA. The treatment of OSA with CPAP has been shown to improve excessive daytime sleepiness[5] and neurocognitive functioning[6,7] and decrease sympathetic neural activity and blood pressure.[8] Mortality may also decrease with CPAP treatment.[9] However, such results are incumbent upon adequate adherence to therapy.[10]

Several factors such as increasing age, [11] mouth breathing, [12] reduction in Epworth Sleepiness Scale score (ESS)[11] and sleep quality during titration night[13] correlate with CPAP adherence. However, the effects of other factors such as race and sex on CPAP adherence are not clear. It is important to understand the variables associated with CPAP adherence so as to focus on these factors in an effort to optimize adherence. Based on the available data, it is not clear how early after initiation of CPAP therapy should patients be evaluated to determine whether they are adhering to the therapy. An early intervention in patients with poor adherence to CPAP may plausibly have a better likelihood of improving adherence rather than intervening later in the course of therapy, when a pattern of poor adherence has already been established.

Studies evaluating sex-related differences in adherence to diverse interventions have reported variable results. Some studies report that women are more adherent to interventions, [14] others have found that women are less adherent to chronic treatments,[15,16] whereas still other studies have reported no differences in adherence to therapies between men and women.[17-19] Similarly, some studies have suggested a difference in adherence to interventions between Caucasians and African Americans.[20,21] Several studies have attempted to explain sex and race differences in CPAP adherence, but the associated factors have not yet been clearly elucidated. The purpose of this study was to further inform the literature by evaluating CPAP adherence in a relatively large patient population.

An additional aim was to determine whether CPAP use at inception predicts long-term CPAP adherence. To this end, we assessed the relationship between early CPAP usage (3-day or 7-day adherence) and long-term (30-day) adherence to CPAP in 100 patients with OSA.

Disclosure Statement

This was not an industry supported study. Dr. Hudgel has received research support from Boehringer-Ingelheim and has been a consultant for Invacare and DeVilbiss. Dr. Roth is a consultant for Abbott, Accadia, Acoglix, Actelion, Alchemers, Alza, Ancil, Arena, AstraZeneca, Aventis, BMS, Cephalon, Cypres, Dove, Elan, Eli Lilly, Evotech, Forest, GlaxoSmithKline, Hypnion, Johnson & Johnson, King, Ludbeck, McNeil, MediciNova, Merck, Neurim, Neurocrine, Neurogen, Novartis, Orexo, Organon, Orginer, Prestwick, Proctor and Gamble, Pfizer, Purdue, Resteva, Roche, Sanofi, Schering-Plough, Sepracor, Servier, Somaxon, Syrex, Takeda, Transoral, Vanda, Vivometric, Wyeth, Yamanuchi, and Xenoport; has received research support from Aventis, Cephalon, GlaxoSmithKline, Neurocrine, Pfizer, Sanofi, Schering-Plough, Sepracor, Somaxon, Syrex, Takeda, TransOral, Wyeth, and Xenoport; and has participated in a speaking engagement supported by Sanofi and Takeda. Dr. Drake is a consultant for Sanofi-Aventis, Remedica Ltd., Cephalon, Pfizer, and Oregon Center for Applied Science and has participated in speaking engagements for Sepracor, CME LLC and CME Outfitters. Drs. Parthasarathy, Sharief, Rohit Budhiraja, Pooja Budhiraja, and Ms. Saunders have indicated no financial conflicts of interest.

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Table 1—Characteristics of the Study Population

Variable	Results
Age, y	53 ±10 (27-84)
Body mass index, kg/m2	39 ± 8 (24-64)
Neck size, inch	17 ± 2 (14-23)
Epworth Sleepiness Scale score	13 ± 6 (2-24)
Sleep efficiency, %	80 ± 12 (20-96)
Oxygen saturation, %	
Average	92 ± 4 (75-96)
Lowest	78 ± 12 (25-95)
Apnea-hypopnea index, events/h	
In NREM sleep	43 ± 29 (4-163)
In REM sleep	40 ± 28 (0-162)
Total	43 ± 28 (5-163)

Data are presented as mean ± SD (range). NREM refers to non-rapid eye movement; REM, rapid eye movement.

METHODS

Subjects

Data from 100 consecutive patients newly diagnosed with OSA (apnea-hypopnea index ≥ 15) at Henry Ford sleep disorders center, who were started on CPAP therapy and had electronic adherence information relayed by the CPAP device through a telephone modem to a laboratory-based computer (SMART-Track modem; e-Compliance, DeVilbiss, Longmont, Colo) were analyzed. Patients were followed for 30 days following CPAP initiation. During the initial clinic visit prior to the diagnostic polysomnography, all patients had age, sex, body mass index, neck size, and ESS score recorded.

Polysomnography

The montage of the diagnostic polysomnography included recordings of electroencephalograms, electrooculogram, submental and leg electromyograms, and electrocardiogram. Airflow was measured by a nasal thermistor, and respiratory effort by thoracoabdominal piezoelectric belts. All studies were scored using previously published criteria.[22] The AHI was calculated as the mean number of apneas plus hypopneas per hour of sleep. Obstructive apneas were identified by the absence of airflow for at least 10 seconds in the presence of thoracoabdominal effort. Hypopneas were scored if the magnitude of ventilation signal decreased less than approximately 50% of the baseline amplitude for at least 10 seconds and were associated with at least 3% drop in oxygen saturation measured by finger pulse oximetry. Central apneas were scored if both airflow and thoracoabdominal effort were absent for at least 10 seconds in duration. Arousals were not required to score apneas or hypopneas. Average and minimal oxygen saturations during diagnostic polysomnography were also recorded.

CPAP Adherence

CPAP adherence was determined using objective data obtained with a modem connected to the CPAP device, which downloaded the data to a central computer to yield objective adherence data in hours per night. Total hours of CPAP use at 3, 7, and 30 days were calculated. We divided the population into those with "good adherence" to CPAP (≥ 4 hours CPAP use per night) and those with "poor adherence" to CPAP (< 4 hours CPAP use per night), as has been done in some prior studies.[12,23-25] The rationale behind utilizing a minimum of 4 hours a night of CPAP use as a cutoff to define good adherence was the fact that this level of CPAP has been shown to attenuate the excessive daytime sleepiness associated with OSA[26] as well as increase supine posterior airway space in patients with OSA, probably by reducing upper airway edema.[27] Usage index was calculated as the number of days the CPAP was used for more than 4 hours divided by the total number of days studied.

Table 2—Correlations Between Continuous Variables and CPAP Machine Use[a]

Variable	Usage index	Average usage hours
Age		
Pearson Correlation	.255[b]	.249[b]
Sig. (2-tailed)	.015	.018
Body Mass Index		
Pearson Correlation	-.056	-.039
Sig. (2-tailed)	.604	.723
Neck size		
Pearson Correlation	.019	-.025
Sig. (2-tailed)	.857	.818
ESS score		
Pearson Correlation	.124	.041
Sig. (2-tailed)	.248	.708
Sleep efficiency		
Pearson Correlation	-.077	-.049
Sig. (2-tailed)	.637	.765
Average oxygen saturation		
Pearson Correlation	.040	.010
Sig. (2-tailed)	.805	.949
Lowest oxygen saturation		
Pearson Correlation	.045	.020
Sig. (2-tailed)	.783	.901
Apnea Hypopnea Index		
Pearson Correlation	.046	.037
Sig. (2-tailed)	.669	.728

[a]In terms of usage index or average daily hours of use
[b]Correlation is significant at the .05 level (2-tailed).

Statistical Analyses

For continuous variables, we calculated Pearson correlations. For categorical variables race and sex, we divided the sample into 2 subgroups (Caucasian or African American and male or female, respectively) and then compared the mean nightly CPAP use and the usage index of the 2 groups, using independent t-tests. Multivariate regression was used to study the effect of particular variables on adherence while controlling for confounding variables. Data were expressed as mean ± SD. All comparisons were 2-tailed, and the statistical significance level was set at $P < .05$ for all tests. Statistical analyses were conducted using SPSS v

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Table 3—Comparisons Based on Hours of Use of CPAP per Night

Variable	CPAP use per night		P Value
	≥ 4 h	< 4 h	
Age, y	53.5 ± 10.4	50.4 ± 10.1	.18
BMI, kg/m^2	38.2 ± 7.9	40.5 ± 9.5	.25
Neck size, inches	17.4 ± 1.8	17.4 ± 2.3	.92
ESS score	14 ± 6	13 ± 6	.42
Sleep latency, min	11.2 ± 18.4	12.4 ± 14.2	.75
Sleep efficiency, %	79.3 ± 12.5	81.9 ± 12.6	.35
Oxygen saturation, %			
Average	91.5 ± 3.6	92.1 ± 3.4	.44
Lowest	77.5 ± 11.7	79.3 ± 13.3	.51
AHI, events/h			
In NREM sleep	44.2 ± 29.5	41.3 ± 29.4	.67
In REM sleep	38.9 ± 28.6	42.0 ± 28.2	.63
Total	44.7 ± 28.0	42.5 ± 28.3	.73

Data are presented as mean ± SD and were calculated 30 days after initiation of continuous positive airway pressure (CPAP) therapy. BMI refers to body mass index; ESS, Epworth Sleepiness Scale; AHI, apnea-hypopnea index; NREM, non-rapid eye movement; REM, rapid eye movement

12.0 for Windows (SSPS Inc, Chicago, IL).

RESULTS

The demographic and polysomnographic characteristics of the sample are described in Table 1. At the 30-day mark, the average nightly CPAP use was 5.0 ± 2.0 hours, and the usage index (number of days the CPAP was used for more than 4 hours divided by the total number of days studied) was 63.5% ± 31.0% for all patients (n = 100). Table 2 shows that, among the continuous variables studied, only age was correlated with CPAP usage index or with average daily CPAP use.

There were no significant polysomnographic differences between those with good adherence (≥ 4 hours CPAP use/night based on 30-day data, n = 73) and those with poor adherence to CPAP (< 4 hours CPAP use/night, n = 27) (Table 3). We compared the 30-day adherence in subjects who used CPAP for either more or less than 4 hours per night at day 3 or day 7. A majority of those with more than 4 hours a night CPAP use at 3 or 7 days went on to use CPAP for 4 or more hours per night at 30 days, compared with only a minority of subjects who had less than 4 hours of CPAP use per night at day 3 or day 7 (Figure 1).

The sample included 65 men and 35 women. The women had a higher body mass index (42.3 ± 9.2 vs 36.9 ± 7.5, P = .003) but a smaller neck size (16.2 ± 1.5 inches vs 18.1 ± 1.8 inches, P < .001) when compared with men but were not different in terms of age, race, ESS score, or apnea-hypopnea index. Body mass index and neck size did not correlate with adherence. The average daily CPAP usage time (5.0 ± 1.9 hours vs 5.0 ± 2.2 hours, P = .9) and usage index (58% ± 32% vs 66% ± 30%, P = .218) were similar in women and men.

Fifty-seven of the subjects were Caucasian, 39 were African-American, and 4 belonged to other races. There were no differences in the other demographic or polysomnographic variables studied between Caucasian and African Americans. Caucasians had higher daily CPAP usage than did African Americans (5.5 ± 2.2 hours vs 4.4 ± 1.5 hours, P = .005).

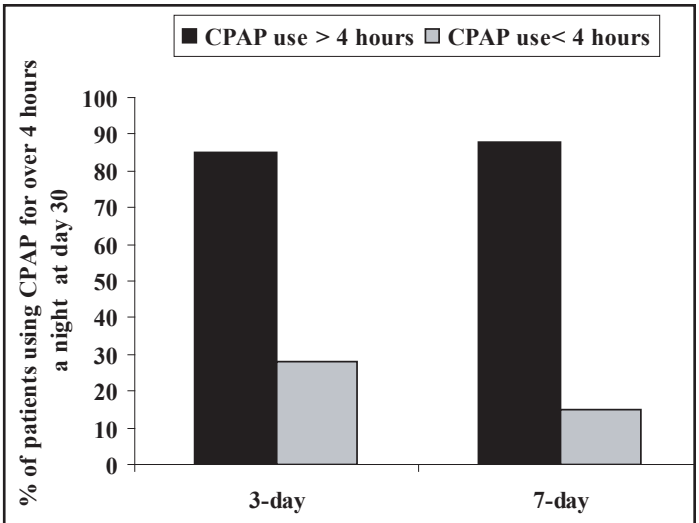

Figure 1—A significantly higher proportion of patients with good adherence to continuous positive airway pressure (CPAP use ≥ 4 night) at day 3 or day 7 were using CPAP for ≥ 4 h/night at day 30 than were patients with poor adherence to CPAP (CPAP use < 4 h/night) at these time points (p < .001 for all comparisons).

DISCUSSION

The primary finding of this study is that, in patients with OSA, the long-term adherence to CPAP therapy can be predicted as early as 3 days after the initiation of CPAP therapy. Furthermore, age and race, but not sex or severity of the disease, were related to CPAP adherence in this rather large sample.

We found that the pattern of adherence to CPAP at 3 days and 7 days strongly predicted longer-term (1-month) adherence. Eighty-four percent of those who used CPAP for more than 4 hours a day at day 3 used CPAP for an average of more than 4 hours a day at day 30, compared with only 26% of those who used CPAP for less than 4 hours a day at day 3. The fact that only a minority of the patients who used CPAP for less than 4 hours per night at day 3 and at day 7 used it for more than 4 hours a night when assessed at day 30 may suggest that, once patients have an initial negative experience with CPAP, the chance of obtaining optimal long-term adherence may be limited.

This study confirms the findings from a study by Weaver et al suggesting that the difference in intermittent CPAP users and consistent CPAP users based on night-to-night variability may be apparent by the fourth day of treatment.[4] Our study may provide a somewhat more representative sample due to the larger number of subjects and greater proportion of women (35% vs 19%) and minorities, compared with the aforementioned study.[4] Another recent study suggested poor adherence to CPAP in patients reporting problems at autotitration.[28] Popescu et al showed that data derived from a 2-week CPAP trial are useful in identifying patients who will be adherent to CPAP therapy at 1 year.[29] These results suggest that the patients should be seen early after initiation of this therapy to address any concerns that might preclude subsequent adherence. In another study, better sleep obtained specifically during the titration night was predictive of better adherence, providing further support for the

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notion that early experiences with treatment may be an extremely important factor in determining subsequent use.[13] Although we did not study the causes of nonadherence to therapy, nasal congestion and discomfort with the mask may be some of the possible factors that may compromise early and subsequent adherence.[30] An unnecessarily high initial CPAP pressure may also be a contributing factor; studies of auto-PAP have demonstrated increased adherence to treatment and lower CPAP pressures with the use of a auto-titrating, self-adjusting device, as compared with traditional CPAP.[31]

Poor adherence to health-related interventions is a common problem in chronic conditions and may have a multifactorial etiology.[32] Factors such as ethnicity, level of education, family support, and patients' perception of their disease and the benefits that may accrue from the intervention influence the adherence to treatment. Behavioral, psychological, social, anatomic, and financial differences may underlie differences in adherence to therapies.[32] In our study, age and race were significant determinants of CPAP adherence, although these other factors were not assessed.

Our results suggest that older people use CPAP for longer hours that do younger people. This finding is consistent with that by Sin et al.[11] Although the current study design did not allow exploration of the cause of lower adherence in younger patients, one speculation is that a presumed or actual hindrance to an active social life caused by the "barrier effect" of the mask may have contributed to reduced adherence.

African Americans comprised a significant proportion of our patients (39% of all subjects). Although we found a lower adherence to CPAP therapy in these patients, any interpretation of these results is markedly limited in absence of any socioeconomic, cultural, biologic, or education indexes. These results should, thus, be considered only exploratory rather than conclusive. Further studies are required to confirm the race-related differences in CPAP adherence and, if present, elucidate the possible underlying etiologies.

Adherence to CPAP therapy for OSA has been the focus of some recent studies. Intensive follow-up and education improve CPAP adherence.[33-35] Sin et al found a 3-times higher long-term adherence in women compared with men.[11] Other studies of adherence to CPAP therapy have had predominantly male subjects and, thus, were not powered to find any adherence differences between the sexes.[28,35-38] Our study had 35% females, allowing us to make reasonable conclusions regarding sex differences in CPAP use. However, in contrast with the study by Sin et al,[11] we did not find any sex-related differences between any of the different definitions of CPAP adherence. The factors underlying the difference in the results from 2 studies are not clear. However, some differences in the 2 studies can be speculated as the potential causes of this difference. The study by Sin et al had a lower percentage of women with OSA (19%) than in the current study (35%). The ethnic breakdown of the population is not available in the former study. Finally, the usage index (number of days the CPAP was used for more than 4 hours divided by the total number of days studied) in that study was 83%, compared with 63% in the current study, suggesting that our sample was significantly different from that of the Sin et al study.

Our study also did not find an association between the severity of the OSA and adherence to treatment. This is similar to the results of prior studies.[6,10,39] Similarly, ESS score prior to initiation of the therapy did not predict CPAP adherence. Some prior studies have also failed to show a significant association between ESS score and long-term adherence to therapy.[40] Although McArdle et al demonstrated an association between ESS and CPAP adherence,[41] other studies have suggested that a fall in ESS rather than the absolute ESS at baseline may better predict CPAP adherence.[11]

Although some studies have assessed adherence to the therapy using hours on a meter present on the machine, such data may not provide optimum objective information regarding CPAP use.[4] Hence, we utilized a commercially available modem that automatically downloads usage data and transmits it to a central server using a telephone line, providing a highly accurate estimate of overall CPAP use. This technique also permits an accurate analysis of daily CPAP use.

Our study has several limitations. The retrospective design of the study may allow introduction of selection bias. However, we obtained data on all 100 consecutive patients who met the selection criteria. Second, our population included a significant proportion of African-American subjects and may not be generalizable to all populations. Third, we followed the patients with "modem-based" adherence measures for only 1 month. However, earlier studies demonstrated that long-term adherence to CPAP therapy may be comparable to that at 1 month.[24] Fourth, in the absence of a standard definition of "good adherence" or "poor adherence" of CPAP, we empirically chose use of CPAP longer than 4 hours a night to define good adherence. This was based on studies showing a decrease in daytime symptoms and upper-airway edema associated with OSA with more than 4 hours of daily CPAP use.[26,27] Furthermore, we repeated the analyses using different definitions of consistent CPAP adherence (more than 4 hours a night for 60%, 70%, or 80% of all nights, analyses not shown) and came to the same conclusion regarding predictors of 30-day use as with the definition used in the current study. Finally, the variables evaluated in this study explain only a small portion of the variance in CPAP adherence. Factors such as patient experience on the CPAP titration night, patient education, patient support, and psychological factors may also be important in continued adherence to this therapeutic modality[13,35,37,42] but were not evaluated in our study.

In summary, we found older age and Caucasian race to be determinants of increased CPAP use. Specific strategies aimed at younger patients and African-American patients may help improve CPAP adherence in these populations. Our study also demonstrates that the early pattern of CPAP adherence is predictive of sustained long-term use. Thus, emphasis should be placed on assessing the patient early after initiating the CPAP therapy (as early as 3 days) and treating or impacting factors that may negatively influence adherence.

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