Sleep During Titration Predicts Continuous Positive Airway Pressure Compliance

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Study Objectives: Poor compliance with continuous positive airway pressure (CPAP) has been identified as a significant obstacle in the treatment of obstructive sleep apnea. While previous studies have focused on diagnostic screening variables, side effects, health beliefs, and measures of disease severity, investigators have generally ignored sleep parameters assessed during CPAP titration as predictors of compliance. As the titration night represents patients’ initial exposure to nocturnal CPAP treatment, we hypothesized that nocturnal polysomnographic (PSG) variables, representing improved sleep at this time, would predict higher subsequent compliance.

Design: Prospective analyses of a sequential case series were undertaken using nocturnal PSG variables during titration as early predictors of CPAP compliance.

Setting: Accredited sleep center.

Patients: Seventy-one patients with sleep apnea, aged 31-78 years, with a mean respiratory disturbance index of 62.0 ± 32.2.

Interventions: N/A

Measurements and Results: Compliance was calculated as mean hours per night of CPAP use over the initial follow-up period (mean 46.9 days). Standard PSG variables and subjective reports of sleep were used as predictive variables in multivariate analyses. Mean objective compliance was 5.04 hours per night ± 2.59. Consistent with our hypothesis, the best predictor of compliance was change in sleep efficiency (SE) from diagnostic to titration night \[ F (1,66) = 17.31, p < .000 (r = .48) \], indicating that patients whose sleep improved most on the titration night had the highest levels of compliance. This relationship was also significant after controlling for measures of disease severity obtained during the diagnostic testing night. Importantly, individuals whose sleep improved on the CPAP titration night had nightly compliance rates of approximately 2 hours greater than patients whose sleep did not improve during titration.

Conclusions: The findings suggest that patients’ initial experience with CPAP treatment and, in particular, the degree of improvement in sleep during CPAP titration may be crucial factors in determining their subsequent use of this treatment modality.

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INTRODUCTION

CONTINUOUS POSITIVE AIRWAY PRESSURE (CPAP) HAS BEEN DEMONSTRATED AS AN EFFECTIVE TREATMENT FOR PATIENTS WITH OBSTRUCTIVE SLEEP APNEA (OSA). However, poor compliance with CPAP has been identified as a significant obstacle in the successful treatment of OSA. The degree of compliance with CPAP is a significant factor in determining improvement in daytime sleepiness and other health-related outcomes, and it has been shown that compliance during the initial months of therapy predicts long-term use. Most studies in the United States have estimated that patients who have been prescribed CPAP use their machines between 4.5 and 5.5 hours per night. Considering that laboratory studies of sleep restriction have demonstrated significant impairment in objective measures of alertness following as little as 1 night with 6 hours of sleep, this level of nightly CPAP use may not be adequate to eliminate the behavioral morbidity associated with OSA. While studies have shown that beneficial effects are produced with compliance rates as low as 5.1 hours per night, the degree of compliance required to “normalize” function has not been adequately determined. Indeed, significant daytime sleepiness can be present in patients who have average nightly compliance rates of up to 6.1 hours per night.

The low compliance rates of OSA patients to CPAP treatment have led investigators to propose various methods for improving compliance in this patient population. Specifically, extensive CPAP education programs, intensive outpatient monitoring schedules, and side-effect reduction techniques have all met with limited success.

Although in clinical practice, benzodiazepines are sometimes prescribed to patients to increase tolerance of the CPAP apparatus and to enhance compliance during the initial phases of treatment, the effect of this intervention on long-term compliance rates has not been studied. In one recent long-term randomized cross-over trial of auto-titrating CPAP (auto-PAP) versus standard CPAP, individuals used the auto-PAP more than the standard CPAP and, based on dropout data, individuals using auto-PAP were more likely to continue treatment. However, auto-PAP was still used for only approximately 6 hours. Thus, additional methods for improving CPAP compliance are needed.

Determining the specific reasons for compliance could help provide better ways to improve treatment adherence to CPAP. Several studies have been directed toward identifying individual patient factors associated with compliance. Studies have focused on clinical parameters and disease severity both before and after treatment, and psychological measures, as well as side effects associated with CPAP use. Each of these areas of investigation has produced equivocal findings, although there appears to be increasing evidence that greater disease severity is associated with higher levels of compliance. Not surprisingly, there appear to be multiple factors associated with adherence to CPAP treatment. One area that has not been studied extensively is the investigation of factors associated with a patient’s initial exposure to CPAP that may influence compliance. Clearly, the degree of long-term compliance with a treatment regimen will be partly dependent upon a patient’s initial acceptance or rejection of the treatment modality. Any factors that significantly affect a patient’s initial experience with CPAP could have an impact on her or his subsequent compliance. Thus, the present study was undertaken to investigate possible associations between polysomnogram (PSG) sleep parameters obtained during patients’ initial CPAP titration night and subsequent objective measures of CPAP compliance. We hypothesized that nocturnal PSG variables that represent improved sleep during titration would be positively related to compliance. That is, patient compliance will be related to the degree of improvement in sleep that patients experience during their initial titration night.

Disclosure Statement
No significant financial interest/other relationship to disclose.

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METHODS

Patients

Seventy-one consecutive patients presenting with OSA [respiratory disturbance index (RDI) > 10] to a metropolitan sleep disorders clinic were included. Mean age of the sample was 50.7 ± 10.6 years (range 31-78). The sample included 28 (39%) females and 43 (61%) males. Data were collected during the period from August 2000 to April 2001. To qualify for entry into the study, patients were required to complete a sleep habits/personality questionnaire, have a follow-up visit prior to July 2001, and have an exact CPAP delivery date available for the calculation of compliance rate. Patients with repeat, split-night, or daytime titrations were excluded from the study. As the inclusion of only patients who reported for follow-up within a circumscribed time frame would have precluded the use of consecutive patients and could potentially introduce a selection bias, data were analyzed for all patients who met criteria regardless of time between initial interview and follow-up.

Patients were given a presleep and postsleep questionnaire on both the diagnostic and screening nights. Patients were administered a standard 8-hour diagnostic screening PSG and a standard CPAP titration night with technicians adhering to laboratory guidelines. The beginning of the recording (lights out) was set at each patient’s habitual bedtime, as determined during the initial interview. Both the screening and the titration PSGs included 2 electrooculograms (bi-lateral horizontal), submental recording (lights out) was set at each patient’s habitual bedtime, as determined during the initial interview, and 2 electrocardiograms. All recordings were scored using standard procedures. The RDI was calculated as the mean number of apneas plus hypopneas per hour of sleep.

Compliance with CPAP was determined at a subsequent clinical follow-up visit using pressure-on time counters built into each CPAP unit. Patients were unaware of the presence of the time counters. Objective compliance was calculated as mean hours per night across the initial follow-up period. The mean follow-up time period for all patients was 46.9 ± 38.2 days. Subjective compliance (hours/night) and side effects (4-point Likert scale) were assessed by a short questionnaire given at follow-up. Patients also completed a short 5-factor personality inventory during their initial clinic visit in order to investigate possible associations of this measure with compliance.

Statistical Analyses

Objective compliance is considered the more-accurate measure (vs. subjective estimates), and, therefore, it was used as the primary dependent measure in the present analyses. As disease severity has been reported to be related to compliance in previous studies, bivariate correlations were performed comparing measures of disease severity obtained during the PSG screening night with CPAP compliance during the follow-up period. The disease-severity measures with significant correlations with compliance were included as covariates in the multiple regression equation to control for disease severity when examining titration and subsequent compliance due to the known association of disease-severity measures and compliance, all significant (as determined above) disease-severity measures were first entered into the regression equation. Following this step, PSG measures from the CPAP titration night were entered into the regression equation using stepwise variable entry with a criterion of probability-F-to-enter of .05 or less and probability-F-to-remove of at least 0.1. The results of the multiple regression procedure are detailed below.

SE during CPAP titration was the only significant predictor of objective compliance after controlling for data obtained during the diagnostic testing PSG, including apnea index, number of times the oxygen saturation fell below 85%, percentage of stage 1 sleep, and percentage of stage 2 sleep. [For the full model R² = .27, F = 4.86, p = .001 (for SE, ß = .36, t = 3.3, p = .002)]. An additional analysis was performed examining the partial correlation between SE during titration and compliance while controlling for SE during the diagnostic screening night. The results of this analysis demonstrated that the relationship between SE during titration and subsequent compliance remained strong after controlling for SE during the screening night. Indeed, the best overall predictor of compliance was change in SE from diagnostic to titration night (F[1,66] = 17.31, p < .001 (r = .48)), indicating that patients whose sleep improved most during the titration night had the highest levels of compliance.

Multiple regression was also performed using PSG measures to predict subjective compliance with CPAP. As the apnea index during diagnostic testing was the only variable that significantly correlated with CPAP compliance (r = .34, p < .05), this variable was entered into the equation first as a control for disease severity. Nocturnal PSG variables (SE and percentages of stage 1, 2, 3/4, and REM sleep) obtained during CPAP titration were then entered in a stepwise manner with criteria as above. The full model (R² = .49, p = .05) included only latency to persistent sleep (ß= -.66, t = -2.77, p = .02) as a significant predictor of sub-

RESULTS

Means and standard deviations for subjective and PSG variables obtained during the screening and CPAP titration nights are presented in Table 1. Consistent with previous studies, the mean level of compliance (pressure-on time counters in hours/night) for the sample was 5.04 ± 2.59 hours per night. Subjective compliance, as determined by questionnaire at follow-up, was 5.86 ± 2.02 hours per night. As several measures of disease severity were significantly associated (p < .05) with objective compliance, apnea index (r = .32), number of times the oxygen saturation fell to less than 85% (r = .25), percentage of stage 1 sleep (r = .28), and percentage of stage 2 sleep (r = -.31) were used as covariates in the multiple regression analyses. SE during the initial diagnostic screening night was not associated with compliance (r = -.09, p = .45). In addition, subjective measures obtained from the presleep and postsleep questionnaire, personality inventory, and CPAP side effects were not associated with compliance measures (p > .05 for all).

Multiple regression was used to determine if any PSG variables obtained during CPAP titration were significant predictors of subsequent compliance. In order to decrease the possibility of spurious correlations between CPAP-titration variables and compliance due to the known association of disease-severity measures and compliance, all significant (as determined above) disease-severity measures were first entered into the regression equation. Following this step, PSG measures from the CPAP titration night were entered into the regression equation using stepwise variable entry with a criterion of probability-F-to-enter of .05 or less and probability-F-to-remove of at least 0.1. The results of the multiple regression procedure are detailed below.

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<thead>
<tr>
<th>Table 1—Mean ± SD of polysomnographic and self-report variables during screening and titration nights</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sleep Parameter</strong></td>
</tr>
<tr>
<td>Sleep Efficiency</td>
</tr>
<tr>
<td>Total Sleep Time (hours)</td>
</tr>
<tr>
<td>Latency to Stage 1 (min)</td>
</tr>
<tr>
<td>Latency to Persistent sleep (min)</td>
</tr>
<tr>
<td>Stage 1 Sleep (%)</td>
</tr>
<tr>
<td>Stage 2 Sleep (%)</td>
</tr>
<tr>
<td>Stage 3 and 4 Sleep (%)</td>
</tr>
<tr>
<td>REM Sleep (%)</td>
</tr>
<tr>
<td>RDI</td>
</tr>
<tr>
<td>O₂ Saturation Below 85% (#)</td>
</tr>
<tr>
<td>Subjective Sleep Quality</td>
</tr>
<tr>
<td>Subjective Depth of Sleep</td>
</tr>
<tr>
<td>Subjective Total Sleep Time</td>
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</tbody>
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* p < .05; RDI = Respiratory Disturbance Index (apneas + hypopneas/hour of sleep); REM = rapid eye movement; for Likert measures (ie, quality and depth of sleep) higher scores indicate higher levels of each variable.
jective estimates of CPAP compliance at follow-up.

A secondary analysis was performed to determine the degree of objectively measured nightly compliance with CPAP, depending on whether an individual’s SE increased or decreased during the titration night relative to the diagnostic testing night. Specifically, individuals were divided into 2 groups based upon the change score calculated as the difference between diagnostic and titration nights (titration—diagnostic). Groups were categorized as increased SE or decreased SE during titration based upon the SE change score (titration SE minus diagnostic SE). An independent samples t-test was performed to determine the magnitude of the hourly nightly compliance difference between the groups. The increased SE group (n=33) had a mean nightly compliance rate of 6.12 ± 2.25 hours per night, whereas the decreased SE group (n=38) had a mean compliance rate of 4.09 ± 2.52 hours per night [t(659) = -3.56, p = .001]. Thus, individuals whose SE improved during CPAP titration used their CPAP machines an average of 2.03 hours more per night as compared to individuals whose SE did not improve during titration (Figure 1). A similar multiple regression analysis was performed to predict subjective compliance. Consistent with the previous analysis, individuals whose SE improved during CPAP titration were more likely to comply with treatment 6.76 ± 1.24 hours per night as compared to 5.29 ± 2.2 hours per night for individuals whose SE did not improve during CPAP titration (p = .01).

DISCUSSION

As hypothesized, improvement in sleep during the titration night (ie, increased SE) was associated with greater CPAP compliance during the subsequent follow-up period (mean of 48 days) even after controlling for disease severity. These findings suggest that patients’ initial experience with CPAP treatment may be a crucial factor in determining their subsequent use of this treatment modality. It is recognized that SE during a titration night is a complex variable impacted by patients’ response to CPAP, time needed to achieve ideal pressure, titration protocol, and technical capability of staff.

The identification of SE during titration night as a significant predictor of compliance despite the multiple variables impacting it speaks to the importance of a patient’s first exposure to CPAP. The absence of a correlation between SE at screening and compliance suggests the relationship between SE at titration and compliance is not merely a reflection of initial disease severity.

There are likely to be additional factors beyond the nocturnal PSG variables that could have an impact on compliance with CPAP treatment. For example, the immediate effect CPAP has on the daytime sequelae such as excessive sleepiness and neuropsychological deficits associated with OSA may also influence subsequent compliance. The assessment of nightly compliance and patient variables on a daily basis throughout the initial treatment period may provide more-specific information regarding the complex relationships between daytime impairment, symptom relief, side-effect profiles, and CPAP compliance.

Future research should examine the effects of variables that impact sleep during CPAP titration on subsequent compliance. In addition, focusing increased attention on compliance directly following patients’ first use of CPAP may be warranted, especially in patients with poor SE during titration. Finally, using predictors of compliance obtained during titration may help enable resources, such as CPAP education programs aimed at increasing adherence, to be initiated earlier in the treatment process for certain patients.

REFERENCES