Daytime CPAP Titration*

A Viable Alternative for Patients With Severe Obstructive Sleep Apnea

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Objective: Continuous positive airway pressure (CPAP) is the treatment of choice for patients diagnosed with severe obstructive sleep apnea (OSA). The implementation of CPAP therapy has traditionally been based on full-night titration studies or split-night protocols. This study compared a group of patients who received a regular nocturnal CPAP titration with patients who received a daytime CPAP titration. The objective of the study was to determine if daytime CPAP titration is a viable alternative for the implementation of CPAP treatment in patients with severe OSA.

Study design: Fourteen patients (13 men and one woman) received a daytime CPAP titration (day group). The day group was matched to 18 patients (17 men and one woman) who were titrated under a full-night regular nocturnal study (night group). Eligible patients were those with severe OSA (respiratory event index > 40). The groups were matched by age, sex, and body mass index. Results: Daytime and nocturnal CPAP titration studies yielded sufficient amounts of rapid eye movement (REM) and non-REM sleep to help determine CPAP settings. Importantly, the diurnal and nocturnal CPAP titrations resulted in comparable therapeutic pressures as well as comparable resolution of sleep-disordered breathing. After 1 week of treatment, the groups exhibited similar CPAP use and comparable improvements in subjective sleepiness as indicated by their increase in sleep/wake activity inventory scores.

Conclusions: Daytime CPAP titration studies may be a viable alternative for the efficient and expedient implementation of CPAP therapy among some patients with severe OSA.

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Abbreviations: ANOVA=analysis of variance; CPAP=continuous positive airway pressure; CPSG=clinical polysomnography; NREM=nonrapid eye movement; OSA=obstructive sleep apnea; REI=respiratory event index; REM=rapid eye movement; SaO2=arterial oxygen saturation; SWAI=sleep/wake activity inventory; TIB=time in bed

The use of continuous positive airway pressure (CPAP) as a therapeutic option in patients with obstructive sleep apnea (OSA) is recognized as safe and efficacious. However, there is yet no consensus about what constitutes the most effective and cost-efficient CPAP titration protocol. The American Thoracic Society’s consensus statement in this regard recognizes the need to include various body positions as well as nonrapid eye movement (NREM) and rapid eye movement (REM) sleep in order to determine the optimal CPAP pressure.1 The guidelines, however, do not make specific suggestions as to the timing or duration of CPAP titration studies.

In an effort to expedite treatment, maximize resource utilization, and contain costs, many sleep centers have adopted split-night polysomnographic studies for the diagnosis and treatment of this patient population. Studies utilizing this protocol have demonstrated that a majority of patients with OSA can be diagnosed and titrated on the same night in the laboratory.2–6 However, it is clear from the available studies that some patients may require additional adjustments after the split-night protocol.5,6

The split-night protocol has raised a number of clinical concerns as well. It may potentially interfere with the natural course of the physician-patient interaction. This protocol requires the physician to communicate to the patient the need for a diagnostic
test and to express the rationale of the diagnosis, its severity, and the need for therapeutic intervention within the constraints of the first consultation. This is a difficult task considering that OSA is a chronic condition, particularly because a substantial number of patients only attend the consultation upon their spouse’s insistence. Clinical experience suggests that patients are more receptive to discussing treatment alternatives following a diagnostic test. It has, therefore, become desirable to have alternative therapeutic paradigms that enable prompt implementation of CPAP therapy once the diagnosis is made.7-8 Thus, the purpose of this study was to determine if the use of a daytime CPAP titration in patients with severe OSA, after diagnostic nocturnal clinical polysomnography (CPSG) has been performed, is a viable alternative for the implementation of CPAP treatment.

**Materials and Methods**

Data were gathered from a total of 32 patients with severe OSA (30 men, two women). Severe OSA was defined as a respiratory event index (REI) of ≥40 (with ≥80% of the events being obstructive or mixed), associated with significant arterial oxygen desaturations (index of O2 desaturations below 85% was ≥15). Eligible patients were those with nocturnal sleep schedules in whom, based upon a physician’s (LR or PG) clinical impression and review of the CPSG (the morning after the study), a daytime CPAP titration was justified so as to initiate treatment without further delay (13 men, one woman). The daytime patients were matched, by sex, age, body mass index, and REI, to 18 patients (17 men, one woman) who completed a nighttime CPAP titration following our clinic’s regular protocol. All studies were performed from January through August 1996.

All patients completed an initial questionnaire to assess their symptoms and sleep/wake characteristics (including a shortened version of the sleep/wake activity inventory or SWAI).9 The patients were clinically evaluated by a physician board-certified in sleep disorders medicine. For CPSG, patients were required to refrain from caffeine and or alcohol use for at least 5 h prior to arrival at the laboratory. The patients were instructed to continue all of their prescribed medications. Patients were asked to be at the laboratory 2 h before their habitual bedtime. Patients had electrodes hooked up by trained technicians. Electrode placements included unipolar monitoring of the central and occipital EEGs, electro-oculograms, and submental electromyogram. An ECG, tibial anterior electromyogram to monitor for periodic leg movements, a position monitor, and a snoring microphone were also used. Respiration was monitored with a thermistor at the nose and mouth to detect airflow and by a thorac abdominal strain belt to detect respiratory effort (EPM Resp-Ez; EPM Systems, Midlothian, VA). Oximetry was recorded using a finger oximeter (Biox 3700; Ohmeda; Louisville, CO) worn on the patient’s first or second digit. Subjects were kept in bed for 8 h during all nocturnal recordings. However, in a few instances patients requested a shortened time in bed. Among the latter patients, no one underwent recording for a period shorter than 6 h.

Prospective patients for daytime testing were identified by their treating physician within an hour or two after the patient’s rising time. This decision was based on the severity of their condition, derived from both the clinical evaluation and the morning review of the CPSG. Patients were required to follow a nocturnal sleep schedule and have manifestations of severe OSA. Clinically, patients were required to complain of severe snoring and excessive daytime sleepiness. The polysomnographic criteria are defined above. The physician met with the patients the day after CPSG to review their results and to discuss the need for CPAP titration. Those patients who were unable to stay for daytime CPAP titration (or left before the physician reviewed their CPSG) followed the regular sleep apnea protocol. Patients received an abbreviated CPAP education session that emphasized mask fitting. If needed, patients took their medications following the education session. Patients then ate breakfast and were prepared for their daytime CPAP titration study.

Those patients who followed the regular sleep apnea protocol returned for an office visit (sometimes as soon as the day following the diagnostic CPSG). During the office visit, the patient’s physician reviewed the results of the evaluation and discussed treatment alternatives. For severe cases, CPAP was always recommended as an initial form of therapy. A CPAP education session by a specialized technician immediately followed the consultation. During the CPAP education session, patients were given a brief explanation of the proper use of the CPAP machine, were fitted with a mask, and were allowed to experience CPAP while sitting in a comfortable recliner for 10 to 15 min. Patients were then scheduled for a nocturnal CPAP titration.

A consistent effort at offering daytime titration to all patients with severe OSA was made from January through August 1996. However, as stated above, some patients were unable to stay for a daytime titration, while others left the laboratory before the appropriate physician was able to review their polysomnogram. Thus, group assignment was fortuitous. During the time of data collection, 14 patients with severe OSA completed the daytime protocol. These patients were matched to 18 patients with comparable age and OSA severity who completed the nocturnal CPAP titration protocol.

The same CPSG variables recorded during the diagnostic study were monitored during the CPAP titration studies. The patients initiated their CPAP titration study wearing the mask determined to provide the best fit during the CPAP education session. CPAP trials were initiated at 5 cm H2O with upward titration made in increments of 1 cm H2O to eliminate apnea, hypopnea, and arousals associated with abnormal breathing events, including snoring. The increments were done at intervals of about 10 min. Patients not spontaneously sleeping in the supine position were asked to turn over to the supine position once the CPAP setting was within a therapeutic range. Nocturnal and daytime titrations were done by different technicians. The nocturnal CPAP titration studies consisted of an 8-h CPAP, while daytime CPAP titration studies were at least 5 h long. Daytime titrations were shorter because of staffing limitations. Upon termination of CPAP studies, the treating physician determined the CPAP pressure required for optimum treatment of sleep-disordered breathing. Upon termination of daytime titration, patients completed a CPAP education session focusing on the operation of the equipment. All patients were furnished with a CPAP unit set at their prescribed pressure for 7 to 10 days. These units contained a covert microprocessor to determine their nightly use. The microprocessor monitored the number of hours in which the therapeutic pressure was delivered to the patients each night. It was explained to the patients that the equipment they would be using enabled their physician to monitor their nightly CPAP use. Upon their return to the laboratory for a follow-up clinic visit, the patients were asked to complete a brief questionnaire to determine their symptoms, acceptance and use of CPAP, and levels of
sleepiness (as determined by a shortened version of the SWAI). The nightly use of CPAP was also determined from the CPAP unit.

Each CPSG was scored manually in 30-s segments. An interrater reliability of 90% or better was maintained throughout the study. Hypopneas were defined as a ≥50% reduction of nasoral airflow for at least 10 s. Apneas were scored according to commonly used criteria for airflow cessation of ≥10 s. An REI, defined as the sum of the hypopnea index and apnea index, was calculated for each patient.

The data were analyzed using SPSS 6.1 for Macintosh (SPSS Inc; Chicago, IL). Independent t tests were used for the statistical comparisons between the two groups. Variables were submitted to a one-way analysis of variance (ANOVA) with the timing of CPAP titration (day or night) as the independent variable. Where indicated, repeated-measures analyses were performed with diagnostic and titration CPSG parameters as the repeated measures. Tukey’s post-hoc comparisons were utilized where appropriate.

**Results**

Both patient groups were comparable and fairly representative of patients with severe OSA (Table 1). There were no significant differences in the REI or the index of times when the Sao2 dropped below 85%. However, the index of the number of minutes patients spent with an Sao2 below 85% was significantly higher (p < 0.05) for the day group when compared with the night group. The two groups had comparable levels of daytime sleepiness prior to treatment, as determined by the sleepiness scale of the SWAI. Furthermore, the CPAP pressures required for the normalization of breathing during sleep and the calculated REIs at these pressures were comparable for both groups (Table 1).

The patients’ sleep parameters were submitted to a one-way, repeated-measures ANOVA with the day and night groups as between-subject levels and the diagnostic and titration parameters as repeated measures (CPSG study). Time in bed (TIB) was comparable between the two groups on the diagnostic night. However, TIB was significantly shorter during the daytime CPAP titration (Table 2). Importantly, sleep efficiency was comparable during diagnostic and titration CPSG for both groups. Latency to stage 1 NREM sleep was comparable for both groups on the diagnostic studies, but was significantly shorter during the daytime titration (Table 2). A similar interaction was documented for latency to REM-stage sleep; a shortened REM latency was demonstrated during the daytime CPAP titration when compared with the nocturnal CPAP titration (Table 2).

A significant main effect of CPSG study was documented for stage 1 NREM sleep time with significantly less stage 1 NREM sleep during the titration studies for both groups (Table 2). Time spent in stage 2 sleep during diagnostic and titration studies was comparable for both groups. Patients who underwent daytime CPAP titration demonstrated a significant increase in stage 3/4 sleep from their diagnostic CPSG. However, the night group demonstrated comparable levels of stage 3/4 sleep during both diagnostic and titration studies. The day and night groups documented significantly more REM sleep during their titration studies than during their diagnostic studies (Table 2). Relevant to the viability of the daytime CPAP titration is the amount of time patients in the day group spent asleep and the amount of REM sleep these patients accrued at their therapeutic CPAP pressures. Patients in the daytime titration group slept for a mean of 192 ± 76 min at their therapeutic CPAP settings (ie, the prescribed pressure ± 1 cm H2O). This amount of sleep was comparable to the 211 ± 111 min recorded at therapeutic CPAP settings for the nocturnal CPAP titration group. REM sleep accrual at the therapeutic CPAP settings was also comparable for the two groups. A total of 51 ± 39 and 44 ± 37 min of REM sleep was accrued for the daytime and nocturnal CPAP titration groups, respectively.

Patients returned for a follow-up visit with their physician 1 week after the initiation of CPAP therapy. At that time, their weekly compliance was downloaded from the microprocessor located in

| Table 1—Patient Characteristics* |
|-------------------------------|-------------------------------|-----------------|
| **Age, yrs** | **Night Group** | **p Value** |
| 41 ± 14 | 46 ± 15 | NS |
| **Body mass index** | 40 ± 8 | 38 ± 8 | NS |
| **REI** | 93 ± 54 | 84 ± 31 | NS |
| **Index of times Sao2 ≥85%** | 43 ± 35 | 35 ± 28 | NS |
| **Index of min Sao2 ≥85%** | 26 ± 25 | 12 ± 11 | <0.05f |
| **Excessive daytime sleepiness SWAI (initial)** | 37 ± 6 | 41 ± 12 | NS |
| **CPAP pressure** | 12 ± 2 | 12 ± 3 | NS |
| **Treated REI** | 6 ± 7 | 10 ± 7 | NS |

*Data presented as mean ± SD. NS = not significant
†t test = 2.22
their CPAP unit. Two patients in the day group and three patients in the night group did not use their CPAP machines for the entire week and they were excluded from the compliance analysis. The number of nights in which patients in this study possessed their CPAP was 8 ± 2 nights (day, 7 ± 1 nights; night, 8 ± 2 nights). Patients in the day group used their machines an average of 7 nights (range; 5 to 8 nights) for an average of 4.6 h (range; 1.0 to 7.0 h; median; 5.2 h) each night. Patients in the night group used their machines an average of 6 nights (range; 1 to 8 nights) for an average of 4.3 h (range; 1.0 to 8.3 h; median; 3.7 h) each night. There was not a difference between the groups in the length of possession, the number of nights patients used their CPAP machines, or the average nightly use. Patients also filled out the SWAI questionnaire at follow-up, and the groups demonstrated similar levels of subjective sleepiness (day, 60 ± 18; night, 55 ± 11) after treatment. A one-way, repeated-measures ANOVA with initial and follow-up SWAI scores (CPAP treatment) as repeated measures confirmed the groups to be comparable (Group, F = 0.06; p = not significant). More importantly, however, a significant main effect of CPAP treatment (F = 57.84; P < 0.001) on SWAI scores indicated that both groups experienced a significant improvement in subjective daytime sleepiness after 1 week of treatment (day improvement, 23 ± 12; night improvement, 17 ± 10). There was not a group-by-CPSG-study interaction (F = 4.28; p = not significant) for SWAI scores.

**DISCUSSION**

The results of this study demonstrate that daytime CPAP titration may be a viable alternative for some patients with severe OSA syndrome. While the inclusion criteria required patients to have regular nocturnal sleep schedules, manifestations of severe OSA, and polysomnographic corroboration of severe OSA, further research will be required to accurately determine the ideal patient profile of those most likely to benefit from daytime CPAP titration studies. In this study, daytime CPAP titration after a diagnostic CPSG evaluation provided full documentation of the severity of the patient’s condition and at the same time enabled the physician to discuss the results of the study without delaying the initiation of treatment. From the laboratory point of view, this strategy facilitated the use of resources and shortened the waiting time for patients with severe OSA.

The sleep characteristics of daytime CPAP titration also serve to illustrate the homeostatic nature of sleep. It would seem unlikely that after spending 8 h in bed, patients would be able to tolerate returning to bed for an additional sleep period. Patients in this study did not manifest any difficulties with this strategy, however. Furthermore, the nature of their sleep clearly demonstrated improvements in their quality of sleep. From the perspective of CPAP titration, the daytime studies resulted in comparable amounts of REM sleep, which is critical to deriving the therapeutic CPAP pressures for treatment of this condition. It is of interest that the CPAP pressures derived from the nocturnal and daytime CPAP titration studies were comparable, particularly considering that the nocturnal and daytime CPAP titration studies were done by independent teams of technicians. These results are consistent with the comparable levels of severity that were documented during the diagnostic CPSG studies.

Perhaps the most relevant issue concerning the viability of daytime CPAP titration is the outcome reported by the patients after 1 week of treatment.
The two groups experienced comparable resolution of daytime sleepiness. In addition, their compliance with CPAP was comparable and consistent with our clinical experience of CPAP use during the first week of treatment. Furthermore, this level of compliance is consistent with the compliance rates reported in the literature. However, it must be acknowledged that the assessment of long-term outcome measures would be highly desirable. We are currently making every effort to reach these patients in order to reevaluate their clinical status, CPAP compliance, and need for further titration.

There are limitations to this study that need to be acknowledged. Patients were not randomly assigned to the daytime or nocturnal titration groups. The study was, rather, the result of clinical necessity when physicians felt that a CPAP titration should not be delayed. During the data collection period, every effort was made to offer daytime titration studies to all eligible patients. Many of the patients, however, had already left the laboratory before the physician was available to review and discuss the results of the test. On many other occasions, the patients could not make the necessary arrangements to stay for the day. These patients ended up forming the nocturnal CPAP group. While this group allocation may have resulted in a biased treatment assignment, the severity of the patients’ conditions and demographic characteristics suggest that both groups are comparable. In terms of the methodology of the study, it is always undesirable to derive conclusions based on accepting the null hypothesis. However, the outcome variables, such as average CPAP use per night and patients’ improvement in the level of daytime sleepiness, suggest that a daytime CPAP titration for some severe OSA cases may be a viable protocol for implementation of CPAP. Furthermore, the small differences between the two groups in this study strongly suggest that a very large sample size would be needed to reject the null hypothesis. Such a large sample size would make a study of this nature impractical, and would be of questionable clinical relevance.

The positive results derived from daytime CPAP titration studies has enabled us to incorporate this methodology into our clinical practice. We have found that patients accept this methodology and experience comparable outcomes when compared with patients titrated using the regular nocturnal protocol. However, caution should be exercised as for whom this strategy is a viable therapeutic protocol. Patients with milder degrees of sleep-disordered breathing are unlikely to tolerate this procedure. Thus, excessive utilization of daytime CPAP titration may potentially result in an increased percentage of CPAP failures. Patients with milder degrees of apnea should always be titrated during their regular sleep period.

References
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