Predicting Continuous Positive Airway Pressure from a Modified Split-Night Protocol in Moderate to Severe Obstructive Sleep Apnea-Hypopnea Syndrome

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Abstract

Background Most split-night sleep (SNS) studies have enrolled Caucasian patients with moderate-to-severe obstructive sleep apnea-hypopnea syndrome (OSAHS), with different apnea-hypopnea index (AHI) criteria for diagnosis and successful CPAP titration from the standard full-night study (FNS). This study aimed to describe a shortened diagnostic SNS in the Taiwanese population using diagnostic and CPAP therapeutic criteria identical to the standard FNS, and to generate a predictive equation for effective CPAP (P_{eff}) titration.

Methods A total of 418 patients with moderate-to-severe OSAHS were enrolled in this study. The duration of the diagnostic SNS was shortened to approximately 1-2 hours. The diagnostic accuracy and the success rate of CPAP titration in SNS were evaluated and a statistical model for P_{eff} was built. The accuracy of the predictive equation was validated in another 127 patients.

Results Eighty-nine percent of patients with moderate-to-severe OSAHS diagnosed in the preceding FNS yielded the same grade of OSAHS in SNS. These reproducible patients were more severe, with 88% attaining successful CPAP titration in SNS. The predictive $P_{eff}=1.98+0.184\times\text{BMI}+0.01\times\text{AHI}_{\text{SNS}}+0.016\times\text{DI}_{\text{SNS}}$ ($R^2=0.28$, $p<0.0001$) where BMI was the body mass index and DI the desaturation index. The Δ predictive $P_{eff} - P_{eff}$ was within 2 cm H₂O in 84% of the study group and 73% of the validation group.

Conclusion The modified split-night protocol and the predictive equation for CPAP can be useful in Taiwanese patients with moderate-to-severe OSAHS. Our findings may shorten the waiting time for polysomnography.

Key words: apnea-hypopnea index, respiratory disturbance index, breathing disturbances, polysomnography, sleep disorder

(Inter Med 47: 1585-1592, 2008)

(DOI: 10.2169/internalmedicine.47.1107)

Introduction

Nasal continuous positive airway pressure therapy (nCPAP) has been one of the most effective treatments in managing obstructive sleep apnea-hypopnea syndrome (OSAHS) (1, 2). However, titration to the lowest effective CPAP (P_{eff}) level in order to abolish apnea is time-consuming and costly due to the need for a 2nd or even

more full-night polysomnography (PSG) studies (3). Statistical models for predictive P_{eff} (P_{pred}) have been developed in the full-night studies and predictive P_{eff} has been suggested to serve as a starting pressure, thereby expediting titration in a sleep laboratory (4, 5).

One of the methods to shorten waiting time for a sleep study is the split-night study. It condenses the diagnostic and the therapeutic sleep studies with CPAP into a one-night study, thereby mitigating the demand for sleep studies (6).

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Received for publication March 11, 2008; Accepted for publication June 8, 2008

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Figure 1. Flow-chart of patient selection. PSG: polysomnography; OSAHS: obstructive sleep apnea/hypopnea syndrome; FNS: full-night sleep study; SNS: split-night sleep study; SNS₁: the diagnostic split-night sleep study; SNS₂: the therapeutic split-night sleep study; AHI: apnea/hypopnea index; P_{eff}: the lowest effect CPAP level.

The split-night protocol has been accepted for patients with moderate to severe OSAHS (6-8), but the split-night study does not provide a sufficient amount of time for CPAP titration (9, 10). It is therefore reasonable to develop statistical models for predictive P_{eff} to serve as a starting pressure, thereby facilitating the CPAP titration in the split-night study.

This study had several objectives. First, since most split-night sleep studies reported in the literature were conducted primarily on Caucasian patients, the performance of the split-night protocol in a Taiwanese patient population with moderate to severe OSAHS was analyzed. Second, the performance of the split-night protocol using identical criteria was analyzed in comparison to the full-night protocol. In the full-night protocol, AHI ≥ 15 events/h is an indicator for CPAP titration (11) and AHI < 5 events/h is an indicator for successful CPAP titration (12). In contrast, in most previous reports on split-night study AHI of 5-40 events/h is an indicator for CPAP titration (9, 10, 13-17) and AHI 9-20 events/h is an indicator for successful CPAP titration (7, 14, 15). Third, we wanted to evaluate the performance of a shortened duration of diagnostic split-night protocol as McArdle et al utilized in their study (15), since the standard duration of di-

agnostic split-night study has been suggested to be ≥ 2 hours, which might leave the remaining sleep time insufficient for CPAP titration (9, 10). Lastly, we developed a predictive equation of P_{eff} to serve as a starting pressure for CPAP titration in the split-night protocol for future clinical applications.

Methods

Study design

This is an observational retrospective study of a split-night protocol for subjects already diagnosed with at least moderate OSAHS by a preceding full-night polysomnography. Predictive equations of P_{eff} were derived and cross-validated.

Study subjects

A total of 418 Taiwanese patients with moderate to severe OSAHS and who underwent a split-night protocol were analyzed as the study group (Fig. 1 and Table 1). Moderate to severe OSAHS was defined as an AHI ≥ 15 events/hour during a total sleep period of ≥ 4 hours, with observed epi-

sodes of rapid eye movement (REM) sleep.

To validate the robustness of the predictive equation for P_{eff} , another group of patients with suspected classic symptomatic OSAHS were enrolled as the validation group. They explicitly underwent a single split-night protocol without performing a predetermined full-night protocol. "Classic" symptoms were defined as the presence of loud snoring, witnessed apneas, and excessive daytime somnolence (15). The Human Subjects Committee approved this research protocol. All patients gave informed consent.

Protocol

Electroencephalogram (EEG) (C3-A2, C4-A1), chin electromyogram, electrooculogram, electrocardiogram (modified V2 lead), airflow, respiratory effort, and snoring recording were recorded continuously on a polygraph (18) (Nicolet-Ultrasom, Madison, WI, U.S.A.). The arterial oxyhemoglobin saturation (SaO_2) was measured using a finger pulse-oximeter (S_pO_2) (19) (Ohmeda Biox 3740 Oximeter, BOC Health Care Company, Louisville, CO, U.S.A.) and updated every second, averaged every 3 seconds, displayed continuously throughout the test, and integrated to the online recorded polygraph. Respiration airflow at the nose and mouth was measured simultaneously using a thermocouple (20).

Sleep stages were manually scored according to standard criteria (12, 18, 21). Apnea was defined as the absence of airflow for more than 10 seconds, with hypopnea being a decrease of 50% or more in airflow associated with a $\geq 4\%$ decline in oxyhemoglobin saturation. The apnea-hypopnea index was the total number of apneas plus hypopneas divided by total sleep time in hours (4, 19, 22). The severity of OSAHS was graded as "mild" if AHI was from 5 to 14 events per hour, "moderate" if AHI was from 15 to 30 events per hour, and "severe" if AHI exceeded 30 events per hour (23). Since nasal airway pressure was not measured in the study, AHI was used but not the respiratory disturbance index, which included AHI and respiratory event-related arousals (23).

Oxyhemoglobin desaturation was defined as a decrease in S_pO_2 by $\geq 4\%$ for at least 5 seconds. The desaturation index, defined as the total number of desaturation events divided by the total sleep time in hours, was determined to assess S_aO_2 . The modified diagnostic split-night study was started with no CPAP titration for 1-2 hours. Once AHI was ≥ 15 events/h regardless of REM sleep or supine sleep during this period, CPAP titration was conducted for the rest of the sleep time. If AHI was < 15 events/h in the period lasting for > 2 hours, CPAP titration was also conducted based on the previous full-night study but the data were excluded from analysis due to the purpose of the study.

The total sleep time for the split-night protocol was the sum of time spent in the diagnostic and the therapeutic split-night parts. The starting pressure was set at 3 cm H_2O , which was increased until the patient fell asleep, as determined by EEG recordings. The explicit target of CPAP titration was the elimination of apneas and respiratory event-

related arousals, but not airflow limitation due to utilization of thermocouple, thereby leaving AHI for the indicator of pathophysiologic disturbances as suggested in the literature (23). If apnea or hypopnea occurred more frequently than 5 events/h or if 4 apnea-hypopnea events occurred in rapid succession, the pressure was increased by 1-2 cm H_2O (4). The optimal P_{eff} was determined by one of the authors based on the pressure required to maintain the AHI < 5 events/h and all $S_pO_2 > 90\%$. If an AHI < 5 events/h was achieved yet the $S_pO_2 < 90\%$, additional O_2 was administered. A successful split-night study was defined as having all of the following parameters: 1) total sleep period > 4 hours; 2) sleep efficiency $> 50\%$; and 3) the P_{eff} able to abolish apnea with AHI < 5 events/h in the therapeutic split-night portion.

Measurements

Demographics

Clinical characteristics relating to the severity of OSAHS were collected from all of the patients. Data included age, gender, body mass index, neck circumference, daytime somnolence score, history of smoking, and history of hypertension. Daytime somnolence of the subjects was assessed using the Epworth Sleepiness Scale (24, 25). A score > 10 indicated the presence of excessive daytime sleepiness but did not correlate well with OSAHS severity based on the AHI (26).

Polysomnographic variables

Measurements included sleep duration, sleep stages, AHI, desaturation index, and P_{eff} .

Statistical analysis

Paired t test or two-sample t test was used when indicated. The relationship of the polysomnographic measurements between the full-night protocol and split-night protocol in the study group was quantified using Pearson's correlation coefficients, according to duration of the diagnostic split-night protocol. Multiple linear regression was used to model the effects of several anthropometric and polysomnographic variables on the actual P_{eff} during the split-night protocol. All of the predicted pressures according to the fitted equation coefficients were rounded off to the nearest integer in the titration. Thus, the absolute value of the prediction residual, $|P_{pred} - P_{eff}|$, had a limited number of possible values.

We also assessed the model performance and determined the final predictive model by viewing the distribution of $|P_{pred} - P_{eff}|$ and comparing the percentages of $|P_{pred} - P_{eff}| \leq 2$ cm H_2O as in our previous report (4). Traditional measurements for model-fit in linear regression, such as R-square, were used only as screening tools for the candidate models when applying an all-possible-subset model-selection algorithm. All p values were two-sided and were considered at < 0.05 . All of the statistical analyses were performed using the SAS system version 9 (SAS Institute Inc., Cary, NC) and Micro-

Table 1. Characteristics and Full-night Polysomnographic Data of Patients with Moderate-to-severe Obstructive Sleep Apnea/Hypopnea Syndrome (OSAHS) (n=418) and the Full-night Polysomnographic Data of Patients Divided According to Apnea-hypopnea Index (AHI) $\geq 15/h$ (n=373) and $<15/h$ (n=45) in the Diagnostic Split-night Sleep Study

Variables	Groups	Total	Reproducible [⊕] (AHI $\geq 15/h$)	Irreproducible [⊕] (AHI $< 15/h$)
N		418	373	45
Male/female gender, No.		389/29	349/24	40/5
Age, years		49 $\pm$ 12	49 $\pm$ 12	48 $\pm$ 13
Body mass index, kg/m ²		28.4 $\pm$ 4.4	28.4 $\pm$ 4.3	28.5 $\pm$ 5
Neck circumference, cm		41 $\pm$ 4	41 $\pm$ 4	40 $\pm$ 4
Epworth sleepiness scale score		12 $\pm$ 5	12 $\pm$ 5	11 $\pm$ 5
Apnea/hypopnea index, sessions/hour		58 $\pm$ 23	61 $\pm$ 22	35 $\pm$ 21 [‡]
Desaturation index, sessions/hour		29 $\pm$ 22	31 $\pm$ 22	10 $\pm$ 9 [‡]
Sleep period total, min		339 $\pm$ 30	341 $\pm$ 27	324 $\pm$ 47 [¶]
Sleep efficiency (%)		71 $\pm$ 16	72 $\pm$ 15	68 $\pm$ 24
Latency, min		15 $\pm$ 18	14 $\pm$ 16	23 $\pm$ 27 [¶]
Stage 1 (%)		46 $\pm$ 17	48 $\pm$ 16	31 $\pm$ 14 [‡]
Stage 2 (%)		18 $\pm$ 16	16 $\pm$ 15	28 $\pm$ 19 [‡]
Stage 3 (%)		1 $\pm$ 3	1 $\pm$ 3	2 $\pm$ 3*
Stage 4 (%)		0 $\pm$ 3	0 $\pm$ 4	0 $\pm$ 1
Rapid eye movement stage (%)		9 $\pm$ 6	8 $\pm$ 5	10 $\pm$ 7

Mean $\pm$ standard deviation. Sleep period total = the time of awake, rapid eye movement (REM) sleep and non-REM sleep. Latency: duration of time between light off and sleep detected by EEG. * $p < 0.05$, [¶] $p < 0.001$, [‡] $p < 0.0001$. [⊕] Reproducible: indicating patients who yielded the same grade of OSAHS in the split-night study as they did in the full-night study; Irreproducible: indicating patients who yielded a lower grade of OSAHS in the split-night study.

cal Origin v 4.0 (Microcal Software Inc., Northampton, MA, USA).

Results

Forty-five patients with AHI < 15 events/h in the diagnostic split-night part were excluded from analysis. These patients had less severe OSAHS in the preceding full-night study (Table 1) and also underwent CPAP titration. A total of 373 of 418 (89%) patients with moderate to severe OSAHS yielding the same disease severity in the diagnostic split-night part were retained for analysis (Table 1). The AHI and desaturation index were greater as compared to the preceding full-night study (all $p < 0.05$) due to a shorter duration of the diagnostic split-night part as the denominator while calculating the indexes ($p < 0.01$ and < 0.0001 , respectively) (Table 2). Although there might have been statistical differences, these were not clinically relevant and therefore the disease severity remained the same. Nonetheless, these two indexes were significantly positively related between the diagnostic split-night part and the full-night part (both $p < 0.0001$), and these correlations were time dependent (Table 3).

Sleep efficiency and deep sleep stages were improved (all $p < 0.05$, respectively) with CPAP titration in the split-night

protocol. A total of 327 (88%) patients reached AHI < 5 events/h with 9 ± 2 cm H₂O of CPAP level. Twelve percent failed in the therapeutic split-night part and were more severe in the diagnostic split-night study compared to those who succeeded with CPAP titration (desaturation index 60.3 ± 24.3 vs. 33 ± 24.5 , $p < 0.0001$; AHI 77.9 ± 46.7 vs. 63.4 ± 27.8 , $p = 0.059$).

Patients in the validation group (n=127) were sex- and age-matched but more obese and had higher daytime sleepiness scores, percentage of REM sleep, desaturation index, and effective CPAP as compared to the study group (all $p < 0.05$), while AHI, total sleep time, and non-REM sleep architecture were similar (all $p > 0.05$) (Table 2). A total of 108 (85% of 127) patients reached AHI < 5 events/h with 10 ± 3 cm H₂O of CPAP level. Again, 15% failed in the therapeutic split-night part and had a significantly higher desaturation index but not AHI, as compared to those who succeeded with CPAP titration (56.9 ± 28.7 vs. 42.8 ± 24.6 , $p < 0.05$).

In the model-building set, the “best-fit” model in predicting P_{eff} derived from the split-night protocol of the study group with successful CPAP titration (n=327) was as follows:

$$\text{Predictive } P_{eff} = 1.98 + 0.184 \times \text{BMI} + 0.01 \times \text{AHI}_{\text{SNS}} + 0.016 \times \text{DI}_{\text{SNS}} \\ (R^2 = 0.28, p < 0.0001) [1]$$

where BMI was the body mass index, AHI_{SNS} the apnea-

Table 2. Demographic Data and Comparison of Polysomnographic Data between Two Protocols in the Study Group, and Comparison of the Split-night Protocol between the Two Groups

Variables	Types of sleep study	Study group (n=373)		Validation group (n=127)
		full-night	split-night	split-night
Male/female gender, No.		349/24		124/3
Age, years		49±12		47±10
Body mass index, kg/m ²		28.4±4.3	28.2±4.3 [‡]	30±4.7 [†]
Neck circumference, cm		41±4	40±3	42±3 [†]
Epworth sleepiness scale score		12±5	12±5	13±6*
Apnea/hypopnea index, events/hour		61±22	65±31 [‡]	69±27
Desaturation index, events/hour		31±22	36±26 [‡]	45±26 [†]
Sleep period total [‡] , min		341±27	342±26	337±41
Sleep efficiency [†] (%)		72±15	77±14 [‡]	77±15
Latency [†] , min		14±16	11±11 [‡]	13±25
Stage 1 [†] (%)		48±16	31±11 [‡]	31±11
Stage 2 [†] (%)		16±15	29±14 [‡]	28±12
Stage 3 [†] (%)		1±3	4±5 [‡]	3±4
Stage 4 [†] (%)		0±4	1±2	1±3
Rapid eye movement stage [†] (%)		8±5	15±7 [‡]	17±8 [†]
P _{eff} ^{†, §}		-	9±2	10±3 [‡]

Mean ± standard deviation. [#]it summed up the diagnostic split-night sleep study before using CPAP and the therapeutic split-night sleep study while using CPAP in the study group; [†]the therapeutic split-night sleep study when it was a split-night study; P_{eff}: the lowest effective continuous positive airway pressure. Sleep period total = the time of awake, rapid eye movement (REM) sleep and non-REM sleep. Latency: duration of time between light off and sleep detected by EEG. [§]n = 327 in study group; n=108 in validation group (See Figure 1). *p<0.05, [‡]p<0.01, [†]p<0.001, and [‡]p<0.0001 comparisons between full-night sleep study and split-night sleep study for the study group using paired-t, and comparisons between the split-night sleep study of the study group and the split-night sleep study of the validation group using unpaired-t.

Table 3. Pearson's Correlation of Variables between the Full-night and the Diagnostic Split-night Sleep Study (SNS₁) (n=373) by Time Period before CPAP Titration

Variables	SNS ₁ ≅ 60 min (n = 96)		60-89 min (n = 117)		≥ 90 min (n = 160)		Overall (n = 373)	
	r	p value	r	p value	r	p value	r	p value
Apnea/Hypopnea index	0.28	0.006	0.56	< 0.0001	0.63	< 0.0001	0.50	< 0.0001
Desaturation index	0.43	< 0.0001	0.71	< 0.0001	0.77	< 0.0001	0.65	< 0.0001

≅60 min: mean duration=50±8 minutes; 60-89 min: mean duration=77±8 minutes; ≥ 90 min: mean duration=106±11 minutes; and overall mean duration=89±23 minutes

hypopnea index, and DI_{SNS} the desaturation index measured in the diagnostic split-night protocol.

The predictive equation [1] seemed to overestimate the pressures for patients with a lower optimal CPAP level (i.e., <6 cm H₂O) and underestimate the pressures for patients with a higher optimal CPAP level (i.e., >12 cm H₂O) (Fig. 2, Panels A and B). The results were 84% in the study group and 73% in the validation group with predictive P_{eff} within 2 cm H₂O of the actual P_{eff} despite the duration of the

diagnostic split-night part to either <90 minutes or ≥90 minutes (p>0.05).

Discussion

In this modified split-night study, 89% of Taiwanese patients with moderate to severe OSAHS yielded the same disease severity with the full-night study, thereby possibly leaving approximately 10% of patients omitted for CPAP ther-

Figure 2. Panel A: Scattergram of the actual effective pressure levels of CPAP and predictive effective pressure levels using $P_{pred}=1.98+0.184\times BMI+0.01\times AHI_{SNS}+0.016\times DI_{SNS}$. For abbreviations, please see the text. Oblique thick solid line indicates the line of identity; middle thin oblique line indicates the regression line. Panel B: Distribution of the pressure residuals plotted against pressure levels of CPAP in the study group and the validation group.

apy due to false-negative results. In 88% of these reproducible patients, optimal effective CPAP levels were reached despite using stricter indicators for CPAP titration and successful CPAP titration as compared to previous reports (7, 9, 10, 13-17). Twelve percent of patients failed in CPAP titration with the modified split-night protocol; in contrast, 4% of patients failed in CPAP titration with the full-night titration protocol reported in our previous study (4). In the split-night study 73%-84% of patients had predictive P_{eff} 2 cm H₂O within the actual P_{eff} . The proportion seemed modestly lower in contrast to our previous report, i.e., 86% (4). The predictive equation for P_{eff} in the split-night study had R^2 of 0.28 and 0.18 in the current study and previous study (14), respectively, while the predictive equation for P_{eff} in the full-night study had R^2 of 0.44 and 0.76 in our previous report (4) and in another report (5), respectively. The results suggest that the two full-night protocols remained superior to the split-night protocol. However, the split-night protocol using predictive equations of P_{eff} may serve as a starting pressure for CAPA titration and potentially mitigate the demand for two overnight sleep studies. The merit of this strategy might outweigh the modestly lower accuracy in diagnosis and therapy and prediction of P_{eff} . Nevertheless, the split-night strategy seemed more flexible for clinicians to use (13-15). If the subject had low AHI during the diagnostic period, the diagnostic part might be expanded into a full-night protocol, thereby reducing the false-negative diagnostic rate in the split-night protocol.

In this study 11% of patients failing to yield the same disease severity during the modified split-night protocol had less severe disease in the preceding full-night study. The re-

sults were compatible with previous reports that split-night study was not suitable for patients with less severe OSAHS (6-8). The differences in AHI between the full-night protocol and the diagnostic split-night study was approximately 7% in the present study and within 15% in a previous report (15).

The duration of the total recording time of a diagnostic split-night part had been suggested as a time period from two to four hours (6, 7, 27), in contrast to our study range of 1 to 2 hours and a previous report of 82 to 113 minutes (15). There might be some concerns on a shortened diagnostic protocol: 1) too little REM sleep is not representative of the 2nd part (13), which might influence the relationship of CPAP between the therapeutic split-night protocol and the full-night protocol (28); 2) too little variation in body position; and 3) high sleep pressure at the beginning of the night. In this study, a segment of REM sleep during the diagnostic split-night part did not improve performance or increase R^2 while generating the predictive equation. Moreover, the AHI and desaturation index were even higher in the split-night study as pair-compared with the full-night study despite being similar in the grading of the severity of OSAHS (Table 2). While sleep position was related to AHI, it was less important in grading the severity of OSAHS in obese patients with OSAHS and lateral recumbence did not reduce CPAP levels (29). A high sleep pressure in patients at the beginning of the night might be resolved by a good communication between the polysomnographers and patients. Of note, the duration of P_{eff} in the therapeutic split-night part was 99 ± 52 minutes/ 160 ± 55 minutes in this study, in contrast to 123 ± 64 minutes/ 340 minutes and data not reported/ 176 ± 97 minutes in the literature (14, 15). The high proportion of duration of P_{eff} in the therapeutic split-night part in our study was probably due to a shortened diagnostic split-night protocol.

In this split-night study, we generated a prediction equation for P_{eff} (equation 1) with $n=327$, $R^2=0.28$ and $p<0.0001$. In contrast, the equation generated in another split-night study by Iber et al was: Predictive $P_{eff}=3.47+0.107\times BMI+0.023\times AI$ ($n=323$, $R^2=0.18$, $p<0.005$) (14). BMI was more heavily weighted in our equation. This confirms findings from other studies of Asian subjects with OSAHS that demonstrates more severe disease and with less obesity compared to the Caucasian population. This suggests that race and ethnicity plays an important role in the pathogenesis of sleep-disordered breathing (30, 31). AHI plus desaturation index in our equation weighted commensurately with AI in the equation reported by Iber et al (14), as shown in the sum of coefficients. However, the correlation coefficients of both studies were rather low. Although there is something else that might contribute to the predictive pressure due to the low R^2 s in these two studies, adding a long diagnostic split-night study for 2-4 hours might not be the factor since the R^2 was even lower in their report than in ours. Moreover, the performance of the prediction equation was not influenced by the duration of the diagnostic split-night study,

which merely influenced the correlation of AHI and desaturation index between the diagnostic split-night study and the full-night protocol (Table 3). Miljeteig and Hoffstein reported a regression model in a full-night study accounting for 76% of the variability in CPAP (5). In 82% of the patients in our previously reported full-night study, the predictive P_{eff} was within 2 cm H₂O of the P_{eff} when we utilized their equation (4). Despite the predictive equation accounting for merely 28% of the variability in CPAP in the current split-night study, the predictive P_{eff} lies within 2 cm H₂O of the P_{eff} in 73-84% of patients. One might argue what additional information the predictive formula provided to prior attempts in the literature - a rough fit at best. This point of view might not be the best answer for our patient population. Using the prediction equation, the P_{eff} might be achieved with just some "fine-tuning" of the predictive P_{eff} , which should be superior to a fixed level of 10 cm H₂O, for example. Auto-CPAP would facilitate CPAP titration and lower the need for CPAP titration in a sleep lab (32). However, an auto-CPAP device would be more expensive than a standard CPAP device and auto-CPAP protocols have not yet been universally accepted as a starting point for diagnostic purposes (23).

The study had several limitations. As a retrospective analysis, the study did not involve the sensitivity and specificity test to a modified split-night protocol and could not ascertain the accuracy of CPAP titration. Owing to loss to follow-up in the patients who failed in CPAP titration in the

modified split-night protocol, only 12 patients received a subsequent full-night CAPAP titration. Ten of the 12 patients succeeded in CPAP titration and the remaining two patients still failed due to severe nasal obstruction in one and mouth breathing while applying the CPAP in the other. Nevertheless, we found that CPAP levels (9 ± 2 vs. 8 ± 2 cm H₂O) were similar between the split-night study and the full-night study reported previously (4, 10). Also it was reported that eventual CPAP levels fall after two weeks of therapy (33, 34). Lastly, we did not track the compliance of domiciliary CPAP use in patients who succeeded in the modified split-night protocol.

In conclusion, a modified split-night protocol would be feasible for the Taiwanese patient population with moderate to severe OSAHS using indicators for CPAP use and criteria for successful CPAP titration identical to the full-night protocol. Since the modified split-night protocol would probably be inappropriate for patients with less severe OSAHS and CPAP titration would probably fail in some severe patients, polysomnographers should be cautious in performing the split-night protocol and adjusting CPAP levels for these patients. Further study is necessary to determine whether or not a predictive equation of P_{eff} can assist CPAP titration.

Acknowledgement

The authors wish to thank the National Science Council of the Republic of China for financially supporting this research under Contract No. NSC 91-2320-B-010-088.

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