ORIGINAL ARTICLE

pISSN 2093-9175 / eISSN 2233-8853
Sleep Med Res 2011;2:63-68

Subjective and Objective CPAP Compliance in Patients with Obstructive Sleep Apnea Syndrome

Ji-Ae Choi, MD, In-Young Yoon, MD, PhD, Eun-Gyeong Han, RN, Sangdon Lee, MD

Department of Neuropsychiatry, Seoul National University Bundang Hospital, Seongnam, Korea

Background and Objective This study aimed to investigate objective and subjective continuous positive airway pressure (CPAP) compliance in patients with obstructive sleep apnea syndrome (OSAS). Moreover, we evaluated the factors and benefits associated with good CPAP compliance.

Methods Subjects were 153 OSAS patients who underwent polysomnography for CPAP titration. Subjective compliance was defined as reported CPAP use of at least 4 hours a day for five or more days per week, and objective compliance was defined as CPAP use of at least 4 hours a day for more than 70% of the time recorded in the CPAP machine.

Results The subjective and objective compliance rates were 34.0% and 20.7%, respectively. Subjectively compliant patients had lower minimum O_2 saturation and higher % of time with O_2 saturation lower than 90% than did patients declining CPAP treatment. Objectively compliant patients had lower insomnia and depression score and lower minimum O_2 saturation than did patients declining CPAP treatment. Daytime sleepiness and subjective sleep quality improved to the same extent in both objectively and subjectively compliant patients.

Conclusions Lower insomnia score and more severe OSA correlate with good CPAP compliance. CPAP effect was comparable between subjectively and objectively compliant patients. **Sleep Med Res 2011;2:63-68**

Key Words Obstructive sleep apnea syndrome, Continuous positive airway pressure, Compliance.

INTRODUCTION

Physicians have considered continuous positive airway pressure (CPAP) to be the optimal therapy for patients with moderate to severe obstructive sleep apnea syndrome (OSAS).[1] Patients with OSA can get many advantages from regular CPAP usage, including improvements in daytime sleepiness and nighttime sleep quality for both the patients and their bed partners;[2,3] reduced risk of cardiovascular disease and neurocognitive impairment;[4,5] and reduced risk of motor vehicle accidents.[6,7] However, CPAP usage may cause certain discomforts that lower its acceptance and adherence rates.[8] Since CPAP is a self-imposed treatment, researchers and clinicians have regarded compliance as the main determinant of CPAP success. Despite many attempts to improve CPAP treatment adherence, the treatment's acceptance and adherence rates are still low.[9] One comprehensive literature review of CPAP acceptance found that less than half of patients initiated CPAP therapy when their physicansc recommended CPAP therapy.[10] Recently Simon-Tuval et al.[11] found that only 40% of patients needing to use CPAP had actually purchased the device.

A number of studies have tried to discern the factors that predict good adherence to CPAP treatment.[2,10,12] The factors that increased CPAP adherence were increased severity of sleep apnea, greater daytime sleepiness, and perceived symptomatic benefits. However, previous studies found these factors did not prove consistently able to predict good compliance[12,13] and several studies were limited by small sample sizes and short follow-up periods.[14,15] Also, inconsistencies regarding the factors predicting good compliance might have resulted from different definitions of CPAP compliance and different ways of measuring compliance.[13,16]

Received: August 1, 2011
Accepted: August 18, 2011

Correspondence
In-Young Yoon, MD, PhD
Department of Neuropsychiatry,
Seoul National University Bundang Hospital,
166 Gumi-ro, Bundang-gu,
Seongnam 463-707, Korea
Tel +82-31-787-7436
Fax +82-31-787-4058
E-mail iyoon@snu.ac.kr

This study aimed to investigate both subjective and objective CPAP compliance rates in OSAS patients, using a clear definition of "good compliance." In addition, we tried to find any factors or benefits that correlated with good CPAP compliance and to explore the differences between objective and subjective compliance regarding benefits and predictive factors.

METHODS

Subjects

The study subjects were patients with OSAS who had undergone both baseline and CPAP titration polysomnography (PSG). All subjects had been referred to the sleep laboratory of Seoul National University Bundang Hospital between November 2006 and September 2009. Among 173 OSAS patients whom we initially included in this study, we were unable to contact 15: 9 patients with changed phone numbers, 4 who did not answer calls, and 2 now living overseas. After we excluded a further 4 patients with insufficient information for this study and 1 deceased patient, the study's final analysis examined 153 patients (Fig. 1). The study protocol was approved by our Institutional Review Board, and each subject provided written informed consent.

Polysomnography and CPAP Titration

We performed nocturnal PSG on all subjects using an Embla™ N 7000 recording system (Embla; Reykjavik, Iceland) with standard electrodes and sensors. Electroencephalography electrodes were applied at C3/A2, O1/A2, and O2/A1, and two electrooculography (EOG) electrodes were applied at the sides of each eye, to record horizontal and vertical eye movements. We applied submental electromyography (EMG) electrodes to the submentalis muscle, and EMG of both anterior tibialis muscles recorded limb movements during sleep. Strain gauges recorded chest and abdominal respiratory movements, and nasal pressure cannulas measured airflow. To measure arterial oxygen saturation, we placed pulse oximeters on subjects' index fingers. Based on the criteria of Rechtschaffen and Kales,[17] we scored every 30-sec NPSG epoch. We defined apnea as a complete cessation of airflow ≥ 10 sec; hypopnea as a 50% reduction in airflow ≥ 10 sec, accompanied by either ≥ 4% desaturation or an EEG recorded arousal;[18] and Apnea-Hypopnea Index as total apnea and hypopnea events per hour of sleep.

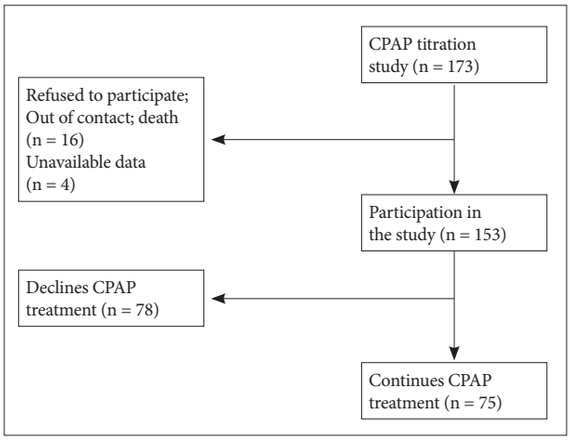

Fig. 1. Study flow chart. CPAP: continuous positive airway pressure.

Based on OSA severity and physical examinations of subjects' upper airways, we recommended that the study subjects use CPAP. Patients with OSAS who accepted CPAP treatment underwent a second polysomnographic study, for CPAP titration. We determined each subject's optimal CPAP pressure as the lowest pressure value that minimized respiratory events and snoring.

Assessments

Prior to the baseline PSG study, we reviewed subjects' medical histories and recorded their anthropometric data [body mass index (BMI) and neck, waist, and hip circumferences]. To determine whether pretreatment symptoms might affect compliance, and whether good compliance could change these symptoms, we had subjects complete several questionnaires before and during their CPAP use. We evaluated excessive daytime sleepiness, subjective sleep quality, and depressive symptoms with the Epworth sleepiness scale (ESS),[19] Pittsburgh sleep quality index (PSQI),[20] and Beck depression inventory (BDI),[21] respectively.

To obtain subjective compliance data, we contacted the subjects via telephone or in-person interviews, and they answered a simple question regarding their CPAP use: how many hours per night and nights per week did they use CPAP treatment? We obtained objective compliance information from data cards inside the CPAP machine. Subjective compliance was defined as reported CPAP use of at least 4 hours a day, for 5 or more days per week, and objective compliance was defined as CPAP use of at least 4 hours a day for more than 70% of the time recorded in the CPAP machine. The non-compliant group comprised patients who declined the CPAP treatment. We asked those who discontinued CPAP by the evaluation time to estimate how long they had used the CPAP device before discontinuation. The patients in this study have received 3 months to 3 years of follow-up.

Data Analysis

SPSS version 15.0 was used for the statistical analysis. We present the results for continuous variables are presented as mean ± SD, and we used a chi-square analysis or independent t-test to examine the differences between the compliant and non-compliant groups. Finally, we applied a paired samples t-test to test the variations in ESS, PSQI, and BDI scores before and after the CPAP treatment. Statistical significance was defined at $p < 0.05$ for two-tailed tests.

RESULTS

Characteristics of OSAS Patients Requiring CPAP Treatment

The baseline demographic and polysomnographic characteristics of OSAS patients are shown in the Table 1. Of the 153 patients, we excluded 12 in our analysis due to missing data. The included subjects' mean age was 53.1 ± 11.4 years, and 87.9% of the subjects were male. As expected, patients requiring CPAP treatment were overweight and had severe OSAS. The average CPAP pressure in the CPAP titration study was 9.4 ± 2.7 cm H_2O.

Table 1. Demographics and clinical characteristics of OSAS patients (n = 141*)

Characteristics	Mean	SD
Age (yr)	53.06	11.44
Sex, male (%)	87.9	
BMI (kg/m²)	27.40	4.27
BDI (score)	8.17	6.69
PSQI (score)	8.42	3.85
ESS (score)	11.58	5.62
RDI (events/h)	54.30	24.53
AI (events/h)	38.44	25.87
Mean O_2 saturation (%)	92.47	7.73
Lowest O_2 saturation (%)	74.87	10.21
% time of O_2 < 90%	17.10	19.20

*Of 153 patients, 12 were not included in the table because of missing data.
OSAS: obstructive sleep apnea syndrome, BMI: body mass index, BDI: Beck depression inventory, PSQI: Pittsburgh sleep quality index, ESS: Epworth sleepiness scale, RDI: respiratory disturbance index, AI: apnea index.

Compliance to CPAP Treatment

Among the 153 OSAS patients whom we had recommended to use CPAP, 52 met our definition of subjective CPAP compliance, and we identified 28 of 135 subjects who provided data cards as objectively compliant patients. Therefore, subjective and objective CPAP compliance was 34% and 20.7%, respectively. About three-fourths (71.8%) of the subjectively compliant patients were also objectively compliant, while 78 patients declined CPAP treatment due to mask discomfort, treatment ineffectiveness, or the inconvenience of being attached to a machine during sleep. Regarding time to discontinuation, 27 patients (34.6%) did not try CPAP therapy after their initial CPAP titration, and 28 patients (35.9%) declined to continue their CPAP treatment within one month (Table 2). The discontinuation rate after 3 months of CPAP use was 15.1%.

Predictors of CPAP Compliance

Table 3 compares the characteristics of subjectively compliant

Table 2. CPAP use discontinuation time among 78 patients

Time (month)	n (%)
Titration only	27 (34.6)
< 1	28 (35.9)
1 ≤, > 3	11 (14.1)
3 ≤, > 6	3 (3.8)
6 ≤, > 12	8 (10.3)
> 12	1 (1.3)

CPAP: continuous positive airway pressure.

Table 3. Differences between subjectively compliant and non-compliant patients

	Compliant patients (n = 48)	Non-compliant patients (n = 73)	p-value
Age (years)	51.96 ± 10.77	55.18 ± 12.40	0.144
Males (%)	89.6	83.6	0.256
BMI (kg/m²)	28.04 ± 4.58	26.73 ± 4.12	0.105
HTN (%)	22.9	30.1	0.255
CPAP pressure (mmHg)	10.13 ± 2.70	9.15 ± 2.69	0.054
BDI (score)	7.88 ± 6.71	9.21 ± 7.05	0.303
PSQI (score)	7.90 ± 3.59	9.26 ± 4.10	0.063
ESS (score)	12.63 ± 5.45	10.86 ± 5.96	0.102
RDI (events/h)	57.77 ± 23.30	51.07 ± 25.72	0.148
AI (events/h)	42.59 ± 25.34	34.12 ± 25.52	0.076
Mean O_2 saturation	90.82 ± 12.61	93.73 ± 2.35	0.120
Lowest O_2 saturation	71.90 ± 10.50	77.82 ± 8.95	0.001
T90 (%)	20.54 ± 20.21	13.06 ± 16.68	0.029

Values are mean ± SD.
BMI: body mass index, HTN: hypertension, CPAP: continuous positive airway pressure, BDI: Beck depression inventory, PSQI: Pittsburgh sleep quality index, ESS: Epworth sleepiness scale, RDI: respiratory disturbance index, AI: apnea index, T90: percent sleep time oxygen saturation was below 90%.

patients and non-compliant patients. Subjectively compliant patients did not differ significantly from non-compliant patients regarding age (p = 0.144), sex (p = 0.256), ESS score (p = 0.102), BMI (p = 0.105), or hypertension (HTN; 0.255). The two groups also did not differ regarding the respiratory disturbance index (RDI; p = 0.148), but the subjectively compliant group had a lower minimum O_2 saturation (p = 0.001) and a higher % of time that O_2 saturation was lower than 90% (p = 0.029) than the non-compliant patients did. Also, the subjectively compliant group had higher CPAP pressure (p = 0.054) and PSQI (p = 0.063), although the difference was statistically insignificant. Objectively compliant patients had lower scores on the PSQI (p < 0.001) and BDI (p = 0.042), a higher BMI (p = 0.037), and a lower minimum O_2 saturation (p = 0.006) than non-compliant patients did (Table 4). However, we found no significant differences between objectively compliant patients and non-compliant patients in ESS score (p = 0.822), RDI (p = 0.107), and % of time that O_2 saturation was lower than 90% (p = 0.113).

Benefits of CPAP Treatment According to CPAP Compliance

Table 5 shows the changes in BDI, ESS, PSQI, and BMI after CPAP treatment. In the subjectively compliant group, we observed a statistically significant reduction in ESS score (11.51 ± 5.2 vs. 7.91 ± 5.58, p < 0.001) and PSQI score (8.00 ± 3.97 vs. 5.66 ± 2.90, p < 0.001). Mean duration of CPAP usage in this group was 19.54 ± 11.00 months. Likewise, ESS and PSQI scores decreased significantly after about 18 months (18.17 ± 10.17) of objectively good compliance with CPAP treatment (ESS 11.14 ± 5.06 vs. 6.50 ± 3.85, p < 0.001; PSQI 6.18 ± 2.65 vs. 4.55 ± 2.11, p = 0.011). Changes in ESS and PSQI score did not differ between the subjectively and objectively compliant groups (ΔESS 3.6 ± 5.4 vs. 4.6 ± 5.2, p = 0.479; ΔPSQI 2.3 ± 3.2 vs. 1.6 ± 2.8, p = 0.393). BDI score decreased significantly in the objectively CPAP compliant group only (6.23 ± 5.38 vs. 4.05 ± 4.30, p = 0.006), but these subjects' average BDI scores were in the normal range before CPAP treatment.

Table 4. Differences between objectively compliant and non-compliant patients

	Compliant patients (n = 25)	Non-compliant patients (n = 73)	p-value
Age (years)	53.68 ± 8.62	55.18 ± 12.40	0.509
Males (%)	88.0	83.6	0.432
BMI (kg/m²)	28.79 ± 4.40	26.73 ± 4.12	0.037
HTN (%)	28.0	30.1	0.527
CPAP pressure (mmHg)	10.32 ± 2.34	9.15 ± 2.69	0.056
BDI (score)	6.04 ± 5.18	9.21 ± 7.05	0.042
PSQI (score)	6.44 ± 2.71	9.26 ± 4.10	< 0.001
ESS (score)	11.16 ± 4.79	10.86 ± 5.96	0.822
RDI (events/h)	60.76 ± 25.68	51.07 ± 25.72	0.107
AI (events/h)	43.62 ± 27.85	34.12 ± 25.52	0.119
Mean O_2 saturation	92.65 ± 2.92	93.73 ± 2.35	0.067
Lowest O_2 saturation	71.88 ± 9.41	77.82 ± 8.95	0.006
T90 (%)	19.41 ± 18.32	13.06 ± 16.68	0.113

Values are mean ± SD.
BMI: body mass index, HTN: hypertension, CPAP: continuous positive airway pressure, BDI: Beck depression inventory, PSQI: Pittsburgh sleep quality index, ESS: Epworth sleepiness scale, RDI: respiratory disturbance index, AI: apnea index, T90: percent sleep time with oxygen saturation below 90%.

Table 5. Changes in BDI, ESS, and PSQI scores and BMI according to CPAP compliance

CPAP compliance		Before CPAP therapy	After CPAP therapy	p-value
Subjectively compliant patients (n = 35)	BDI (score)	8.43 ± 7.08	7.40 ± 8.36	0.348
	ESS (score)	11.51 ± 5.21	7.91 ± 5.58	< 0.001
	PSQI (score)	8.00 ± 3.97	5.66 ± 2.90	< 0.001
	BMI (kg/m²)	28.44 ± 4.62	28.53 ± 3.79	0.829
Objectively compliant patients (n = 22)	BDI (score)	6.23 ± 5.38	4.05 ± 4.30	0.006
	ESS (score)	11.14 ± 5.06	6.50 ± 3.85	< 0.001
	PSQI (score)	6.18 ± 2.65	4.55 ± 2.11	0.011
	BMI (kg/m²)	29.62 ± 3.91	29.37 ± 2.91	0.639

Values are mean ± SD.
BMI: body mass index, BDI: Beck depression inventory, PSQI: Pittsburgh sleep quality index, ESS: Epworth sleepiness scale, CPAP: continuous positive airway pressure.

DISCUSSION

We could classify 34% of OSAS patients who tried CPAP therapy as subjectively compliant to CPAP use, and 20.7% of the CPAP patients showed CPAP compliance based on objective data. Our study's compliance rate was lower than that in previous studies, which showed compliance rates ranging from 40 to 80%.[22,23] However, because of the lack of common criteria for compliance, reported compliance rates have varied across studies, which have occasionally overestimated such rates. Some studies did not include patients who received prescriptions for CPAP but did not obtain the CPAP device.[22,24] We chose a strict definition of CPAP compliance (≥ 4 h use for 70% of days) and computed compliance rates that included the patients who underwent the CPAP titration study only. In addition, the low compliance rate might relate to cultural differences and follow-up strategies after CPAP prescription. In this naturalistic study, we did not have any additional educational programs to improve CPAP adherence.

We evaluated compliance rates based on, not only self-reported data, but also objective data from the CPAP device. Interestingly, about three-fourths of subjectively compliant patients were also objectively compliant CPAP users. Previous studies have found that compliance based on objective monitoring of CPAP use is much lower than is that obtained through self-report.[25,26] This study also supports the idea that OSA patients tend to overestimate their CPAP use, but we found no great difference between subjective reports and objective data. These results demonstrate that subjective reports reflect the realities of CPAP use to a reliable extent, although the determination of objective compliance is important for evaluating CPAP compliance.

In this study, most patients who gave up CPAP therapy discontinued their CPAP treatment within the three months of our CPAP trial. Several previous studies have reported this pattern of use. Rolfe et al.[27] discovered that 78% of treatment interruptions happened within 2 months and 90% within 4 months of prescription. Weaver et al.[15] also found that patients adherent over the first 1 to 3 months tend to continue their CPAP therapy. These data indicate the first few months of CPAP therapy comprise the most critical period for determining long-term compliance, and this underscores that early intervention to improve adherence is essential in CPAP treatment. In this study, about 35% of CPAP-declining patients did not initiate CPAP therapy after their CPAP pressure titration trials. Wolkove et al.[23] similarly reported that one-third of patients did not accept CPAP treatment after receiving an OSA diagnosis and undergoing a CPAP trial. These findings suggest that failing to begin CPAP therapy depends partly on one's first experience and underscore the need for sufficient education and support during the initial titration trial.

Researchers have suggested many factors that possibly predict CPAP compliance.[10,13,28,29] There are no consistent findings across studies, but the well-known factors relating to CPAP compliance include increased OSA severity, excessive daytime sleepiness, improvement in symptoms and/or sleep disturbances, and subjective satisfaction. Regarding the impact of RDI on CPAP compliance, previous studies have given conflicting results.[16,24,30] In this study, we found no RDI difference between the compliant and non-compliant groups. However, compliance correlated with oxygen desaturation during sleep, i.e., nadir SaO_2 and % of time O_2 saturation was lower than 90%. These results support the idea that increased OSA severity correlates positively with CPAP compliance, and degree of nocturnal hypoxemia could be the most sensitive factor for predicting long-term CPAP compliance, more sensitive than respiratory disturbances are.[12,31,32]

In addition, compliant subjects had lower PSQI scores in this study. In several previous studies, CPAP adherence showed no association with PSG sleep measures or subjective reports of sleep quality,[31,33,34] but other studies reported subjectively poor sleep quality in OSAS patients might correlate with difficulty in adhering to CPAP.[35,36] Supposedly, patients with poor sleep quality are sensitive to CPAP's side effects, such as nasal problems, mask discomfort, and noise. Also, sleep disruption and insomnia are symptoms of depression, and researchers have proposed that comorbid depression has a negative influence on adherence to CPAP therapy.[37,38]

These findings suggest physicians need to evaluate patient sleep quality and depressive symptoms before trying them on CPAP treatment, because patients suffering from insomnia or depression may have increased risks of CPAP discontinuation. In concert with other studies' results,[25,28,30,39] both ESS and PSQI scores decreased significantly in the subjectively compliant and objectively compliant group. Both compliant groups showed similar levels of improvement in daytime sleepiness and sleep quality. Pépin et al.[40] mentioned that low CPAP adherence is the most frequent explanation for residual excessive sleepiness during CPAP use.

The relatively short follow-up period, insufficient number of objectively compliant patients, and lack of cardiovascular variables in evaluating CPAP effects could limit this study's implications. However, as a study performed in a real clinical setting, this study might provide a basis for measuring and improving CPAP compliance. In conclusion, this study identified about 70% of subjectively compliant patients as objectively compliant CPAP users, and CPAP's effect in subjectively compliant patients compared to its effect in objectively compliant patients. Most CPAP non-compliant patients discontinued CPAP therapy within the first three months, and higher insomnia and depression scores and less severe nocturnal hypoxemia correlated with poor CPAP compliance in OSA patients. Early intervention is needed to improve CPAP compliance. Clinicians should pay attention to patients who have non-adherence risk factors, such as depression, poor sleep quality, and less severe OSA.

Conflicts of Interest

The authors have no financial conflicts of interest.

REFERENCES

1. Loube DI, Gay PC, Strohl KP, Pack AI, White DP, Collop NA. Indications for positive airway pressure treatment of adult obstructive sleep apnea patients: a consensus statement. *Chest* 1999;115:863-6.
2. Gay P, Weaver T, Loube D, Iber C; Positive Airway Pressure Task Force; Standards of Practice Committee; American Academy of Sleep Medicine. Evaluation of positive airway pressure treatment for sleep related breathing disorders in adults. *Sleep* 2006;29:381-401.
3. Loredo JS, Ancoli-Israel S, Dimsdale JE. Effect of continuous positive airway pressure vs placebo continuous positive airway pressure on sleep quality in obstructive sleep apnea. *Chest* 1999;116:1545-9.
4. Marin JM, Carrizo SJ, Vicente E, Agusti AG. Long-term cardiovascular outcomes in men with obstructive sleep apnoea-hypopnoea with or without treatment with continuous positive airway pressure: an observational study. *Lancet* 2005;365:1046-53.
5. Bardwell WA, Ancoli-Israel S, Berry CC, Dimsdale JE. Neuropsychological effects of one-week continuous positive airway pressure treatment in patients with obstructive sleep apnea: a placebo-controlled study. *Psychosom Med* 2001;63:579-84.
6. Sassani A, Findley LJ, Kryger M, Goldlust E, George C, Davidson TM. Reducing motor-vehicle collisions, costs, and fatalities by treating obstructive sleep apnea syndrome. *Sleep* 2004;27:453-8.
7. George CF. Reduction in motor vehicle collisions following treatment of sleep apnoea with nasal CPAP. *Thorax* 2001;56:508-12.
8. Kakkar RK, Berry RB. Positive airway pressure treatment for obstructive sleep apnea. *Chest* 2007;132:1057-72.
9. Collard P, Pieters T, Aubert G, Delguste P, Rodenstein DO. Compliance with nasal CPAP in obstructive sleep apnea patients. *Sleep Med Rev* 1997;1:33-44.
10. Engleman HM, Wild MR. Improving CPAP use by patients with the sleep apnoea/hypopnoea syndrome (SAHS). *Sleep Med Rev* 2003;7:81-99.
11. Simon-Tuval T, Reuveni H, Greenberg-Dotan S, Oksenberg A, Tal A, Tarasiuk A. Low socioeconomic status is a risk factor for CPAP acceptance among adult OSAS patients requiring treatment. *Sleep* 2009;32:545-52.
12. Budhiraja R, Parthasarathy S, Drake CL, Roth T, Sharief I, Budhiraja P, et al. Early CPAP use identifies subsequent adherence to CPAP therapy. *Sleep* 2007;30:320-4.
13. Sin DD, Mayers I, Man GC, Pawluk L. Long-term compliance rates to continuous positive airway pressure in obstructive sleep apnea: a population-based study. *Chest* 2002;121:430-5.
14. Kingshott RN, Vennelle M, Hoy CJ, Engleman HM, Deary IJ, Douglas NJ. Predictors of improvements in daytime function outcomes with CPAP therapy. *Am J Respir Crit Care Med* 2000;161:866-71.
15. Weaver TE, Kribbs NB, Pack AI, Kline LR, Chugh DK, Maislin G, et al. Night-to-night variability in CPAP use over the first three months of treatment. *Sleep* 1997;20:278-83.
16. McArdle N, Devereux G, Heidarnejad H, Engleman HM, Mackay TW, Douglas NJ. Long-term use of CPAP therapy for sleep apnea/hypopnea syndrome. *Am J Respir Crit Care Med* 1999;159:1108-14.
17. Rechtschaffen AKA. *A Manual Standardized Terminology: techniques and Scoring System for Sleep Stages of Human Subjects.* Los Angeles: UCLA Brain Information Service/Brain Research Institute 1968.
18. Sleep-related breathing disorders in adults: recommendations for syndrome definition and measurement techniques in clinical research. The Report of an American Academy of Sleep Medicine Task Force. *Sleep* 1999;22:667-89.
19. Johns MW. A new method for measuring daytime sleepiness: the Epworth sleepiness scale. *Sleep* 1991;14:540-5.
20. Buysse DJ, Reynolds CF 3rd, Monk TH, Berman SR, Kupfer DJ. The Pittsburgh Sleep Quality Index: a new instrument for psychiatric practice and research. *Psychiatry Res* 1989;28:193-213.
21. Beck AT, Ward CH, Mendelson M, Mock J, Erbaugh J. An inventory for measuring depression. *Arch Gen Psychiatry* 1961;4:561-71.
22. Richard W, Venker J, den Herder C, Kox D, van den Berg B, Laman M, et al. Acceptance and long-term compliance of nCPAP in obstructive sleep apnea. *Eur Arch Otorhinolaryngol* 2007;264:1081-6.
23. Wolkove N, Baltzan M, Kamel H, Dabrusin R, Palayew M. Long-term compliance with continuous positive airway pressure in patients with obstructive sleep apnea. *Can Respir J* 2008;15:365-9.
24. Sucena M, Liistro G, Aubert G, Rodenstein DO, Pieters T. Continuous positive airway pressure treatment for sleep apnoea: compliance increases with time in continuing users. *Eur Respir J* 2006;27:761-6.
25. Rauscher H, Formanek D, Popp W, Zwick H. Self-reported vs measured compliance with nasal CPAP for obstructive sleep apnea. *Chest* 1993;103:1675-80.
26. Kribbs NB, Pack AI, Kline LR, Smith PL, Schwartz AR, Schubert NM, et al. Objective measurement of patterns of nasal CPAP use by patients with obstructive sleep apnea. *Am Rev Respir Dis* 1993;147:887-95.
27. Rolfe I, Olson LG, Saunders NA. Long-term acceptance of continuous positive airway pressure in obstructive sleep apnea. *Am Rev Respir Dis* 1991;144:1130-3.
28. Hoffstein V, Viner S, Mateika S, Conway J. Treatment of obstructive sleep apnea with nasal continuous positive airway pressure. Patient compliance, perception of benefits, and side effects. *Am Rev Respir Dis* 1992;145:841-5.
29. Drake CL, Day R, Hudgel D, Stefadu Y, Parks M, Syron ML, et al. Sleep during titration predicts continuous positive airway pressure compliance. *Sleep* 2003;26:308-11.
30. Waldhorn RE, Herrick TW, Nguyen MC, O'Donnell AE, Sodero J, Potolicchio SJ. Long-term compliance with nasal continuous positive airway pressure therapy of obstructive sleep apnea. *Chest* 1990;97:33-8.
31. Amfilochiou A, Tsara V, Kolilekas L, Gizopoulou E, Maniou C, Bouros D, et al. Determinants of continuous positive airway pressure compliance in a group of Greek patients with obstructive sleep apnea. *Eur J Intern Med* 2009;20:645-50.
32. Sopkova Z, Dorkova Z, Tkacova R. Predictors of compliance with continuous positive airway pressure treatment in patients with obstructive sleep apnea and metabolic syndrome. *Wien Klin Wochenschr* 2009;121:398-404.
33. Wells RD, Freedland KE, Carney RM, Duntley SP, Stepanski EJ. Adherence, reports of benefits, and depression among patients treated with continuous positive airway pressure. *Psychosom Med* 2007;69:449-54.
34. Nguyên XL, Chaskalovic J, Rakotonanahary D, Fleury B. Insomnia symptoms and CPAP compliance in OSAS patients: a descriptive study using Data Mining methods. *Sleep Med* 2010;11:777-84.
35. Edinger JD, Carwile S, Miller P, Hope V, Mayti C. Psychological status, syndromatic measures, and compliance with nasal CPAP therapy for sleep apnea. *Percept Mot Skills* 1994;78:1116-8.
36. Wickwire EM, Smith MT, Birnbaum S, Collop NA. Sleep maintenance insomnia complaints predict poor CPAP adherence: a clinical case series. *Sleep Med* 2010;11:772-6.
37. Kjelsberg FN, Ruud EA, Stavem K. Predictors of symptoms of anxiety and depression in obstructive sleep apnea. *Sleep Med* 2005;6:341-6.
38. Santamaria J, Iranzo A, Ma Montserrat J, de Pablo J. Persistent sleepiness in CPAP treated obstructive sleep apnea patients: evaluation and treatment. *Sleep Med Rev* 2007;11:195-207.
39. Kawahara S, Akashiba T, Akahoshi T, Horie T. Nasal CPAP improves the quality of life and lessens the depressive symptoms in patients with obstructive sleep apnea syndrome. *Intern Med* 2005;44:422-7.
40. Pépin JL, Viot-Blanc V, Escourrou P, Racineux JL, Sapene M, Lévy P, et al. Prevalence of residual excessive sleepiness in CPAP-treated sleep apnoea patients: the French multicentre study. *Eur Respir J* 2009;33:1062-7.