CPAP Adherence of Patients With Obstructive Sleep Apnea

Banu Salepci MD, Benan Caglayan MD, Nesrin Kiral MD, Elif Torun Parmaksiz MD, Sevda Sener Comert MD, Gulsen Sarac MD, Ali Fidan MD, and Gulten Aktin Gungor RN

BACKGROUND: Continuous positive airway pressure (CPAP) and bi-level positive airway pressure (BPAP) are the gold standard treatments for obstructive sleep apnea syndrome (OSAS), but CPAP/BPAP is not well tolerated and requires long-term follow-up. OBJECTIVE: We prospectively assessed subjective and objective adherence and factors that affect adherence in OSAS patients. METHODS: Subjects using CPAP/BPAP were questioned about adverse effects of CPAP/BPAP and were assessed with the Epworth Sleepiness Scale (ESS) at the first, third, sixth, and twelfth month, and once every 6 months after the first year. CPAP/BPAP use and objective and subjective adherence were assessed. Subjects who used CPAP/BPAP for at least 4 hours per night for at least 70% of the days monitored were regarded as adherent, and those who did not were considered non-adherent. The relationships between adherence and demographic data, polysomnography findings, ESS scores, and adverse effects were statistically analyzed. RESULTS: Six-hundred forty-eight subjects who were diagnosed with OSAS by polysomnography and accepted to use CPAP/BPAP in our sleep center between January 2005 and June 2011 were included. Four-hundred fifty-one subjects (69.6%) were men, and 197 (30.4%) were women. Two-hundred forty-eight (38.3%) subjects attended follow-ups, 246 (37.9%) were called by telephone, and 154 (23.8%) could not be reached. Of the whole population, 63.9% had obtained their CPAP/BPAP machine. In the 248 subjects who attended follow-ups, subjective adherence was 85.1% and objective adherence was 64.5%. Improvement in ESS score ($P < .001$) and satisfactory sleep ($P < .001$) were found to be significantly higher in the adherent group. Chest discomfort, difficulty falling asleep, and sleep disturbances were significantly higher in the non-adherent group (all $P < .01$). CONCLUSIONS: Of the whole population, just 38.3% attended follow-ups. The objective adherence was lower than the subjective adherence in subjects who attended follow-ups. Younger subjects were more adherent, and the most important factors that correlated with adherence were substantial improvement of daytime sleepiness and effect of CPAP/BPAP on satisfactory sleep. CONCLUSIONS: CPAP/BPAP adherence should be followed with objective monitoring. *Key words: obstructive sleep apnea; CPAP; adherence; Epworth Sleepiness Scale.* [Respir Care 2013;58(9):1467–1473. © 2013 Daedalus Enterprises]

Introduction

Obstructive sleep apnea syndrome (OSAS) is thought to be present in 2% of female and 4% of male adults. Its prevalence exceeds 8% in men age 40–59 y. In some studies[1-3] it was reported that prevalence was around 20% in men in this age group, and that the prevalence in post-menopausal women was as high as that of men. For OSAS with hypertension, daytime sleepiness, impairment of cognitive functions, ischemic heart disease, and stroke, the gold standard treatment is CPAP, which was first introduced by Sullivan.[4,5] CPAP increases quality of life by eliminating daytime sleepiness, and also decreases

The authors are affiliated with the Department of Chest Diseases, Dr Lutfi Kirdar Kartal Teaching and Research Hospital, Istanbul, Turkey.

The authors have disclosed no conflicts of interest.

Correspondence: Banu Salepci MD. E-mail: bsalepci@yahoo.com.

DOI: 10.4187/respcare.02139

morbidity and mortality rates related to cardiovascular diseases.[6,7]

Efficient CPAP treatment requires regular CPAP use ("adherence"), so factors that affect adherence are of interest to researchers. In general, CPAP adherence is not associated with age, sex, education level, economic status, personality, or the characteristics of the disease, including diagnosis or severity or frequency of symptoms.[5,8] The most important factors that decrease CPAP adherence are skin abrasions and ulcerations caused by the mask, persistent air leak, claustrophobia, nasal congestion, and exhalation difficulties.[5,9] Choosing a CPAP unit with more advanced technology such as an integrated ramp feature, choosing the most comfortable mask, and close follow-up of the patient are factors that increase adherence.[5,10] CPAP adherence is assessed according to duration of use, and there is no specified standard duration. Kribbs et al defined adherence as use of the CPAP machine for $\geq$ 4 hours per night for at least 70% of the days monitored.[11,12] In several studies it was observed that adherence for $\geq$ 6 hours per night was associated with more significant improvement in memory performance and daytime sleepiness.[13-15] In the Kribbs et al study, which is considered one of the best on this subject, patients' self-reports of adherence (subjective adherence) was 60%, but the CPAP machine counters (objective adherence) indicated that adherence was only 46%.[11] We assessed subjective and objective adherence to CPAP and bi-level positive airway pressure (BPAP) and factors that affect adherence in OSAS patients.

QUICK LOOK

Current knowledge

CPAP is an effective therapy for obstructive sleep apnea, but patient adherence to CPAP is poor.

What this paper contributes to our knowledge

Objectively measured CPAP adherence was lower than subjectively reported adherence in the patients who attended follow-up visits. Younger patients had greater adherence, which correlated with significant improvements in daytime sleepiness and more satisfactory sleep.

Methods

Our ethics committee approved the study, and informed consents was obtained from all subjects before polysomnography (PSG) was conducted.

Subjects

Six-hundred forty-eight subjects who were diagnosed with OSAS by PSG and accepted to use CPAP/BPAP in our sleep center between January 2005 and June 2011 were included. The PSG data of the first night and titration night were retrospectively analyzed, whereas follow-ups were recorded prospectively. Subjects whose CPAP/BPAP titrations were unsuccessful and refused a second titration were excluded. Subjects whose CPAP/BPAP titrations were successful but refused CPAP/BPAP due to machine cost or mask discomfort from the beginning were also excluded.

Polysomnography

Standard overnight PS included electroencephalogram, electrooculogram, submental and bilateral leg electromyogram, and electrocardiogram. Air flow was measured by a nasal pressure transducer, and respiratory effort by thoracoabdominal piezoelectric belts. Oxyhemoglobin saturation was measured by a finger pulse oximeter. All signals were collected (Sleep Screen and CephaloPro, Viasys Healthcare, Palm Springs, California) and digitized (Matrix Sleep Analysis software, Aequitron Medical, Minneapolis, Minnesota, and SomnoStar, CareFusion, San Diego, California) on a computerized PSG system operated by experienced technicians. Sleep stages were scored in 30-second epochs, using the Rechtschaffen-Kales[16] and American Academy of Sleep Medicine (AASM) 2007[17] scoring systems. Each epoch was analyzed for the number of apneas and hypopneas. Apnea was defined as cessation of air flow for $>$ 10 seconds, and hypopnea as an air-flow reduction of $\geq$ 50% for $>$ 10 seconds plus an oxygen desaturation of $>$ 3% or an arousal.[17,18] Scorings were made by certificated specialists experienced in sleep medicine. Disease classification was made according to the AASM 2005 guidelines.[19] Subjects were graded according to the AASM 1999[18] criteria, as follows: apnea-hypopnea index (AHI) 5–15 events/h mild, 15–30 events/h moderate, $>$ 30 events/h severe. Subjects who had an AHI $>$ 30 events/h or 5–30 events/h plus risk factors (hypertension, ischemic heart disease, stroke) or daytime sleepiness were prescribed CPAP/BPAP.[5] CPAP titration was performed with an auto-titrating device (AutoSet, ResMed, San Diego, California) with full night PSG, according to the AASM guidelines.[20,21] BPAP titration was performed (VPAP IV, ResMed, San Diego, California) in subjects who could not tolerate high pressures during CPAP titration: subjects who have overlap syndrome and nocturnal hypoventilation. The pressure was set at the minimum needed to abolish snoring, obstructive respiratory events, and arousals, and to improve oxygenation. During titration, nasal or oronasal masks were used.

Procedures

The subjects were admitted to our institution to obtain their CPAP/BPAP machines, with prepared reports and prescriptions based on the titration. The subjects were trained in CPAP/BPAP use by technicians. All the subjects who accepted to use CPAP/BPAP had follow-up appointments set for 1, 3, 6, and 12 months, and every 6 months thereafter. During follow-up visits we assessed Epworth Sleepiness Scale (ESS) score, comorbidities (eg, hypertension, obesity hypoventilation, COPD, cardiovascular diseases, hypothyroidism, diabetes mellitus, depression), history of ear/nose/throat operations (tonsillectomy, nasal septoplasty, uvulopalatopharyngoplasty, nasal polypectomy, radiofrequency ablation), sleep quality (difficulty in falling asleep, sleep disturbances, snoring, noise of the CPAP/BPAP machine, chest discomfort), morning symptoms (dry mouth or nose, headache, waking up tired), and mask related symptoms (skin abrasions and ulcerations, persistent air leak). Mask type (nasal or oronasal) and presence of built-in heated humidifier were noted. CPAP/BPAP machine time on counter (objective adherence) was compared with subjects' self-reports (subjective adherence). CPAP/BPAP usage was calculated as total hours of CPAP/BPAP used/number of days passed since the beginning of CPAP/BPAP use. We defined adherence as $\geq$ 4 hours per night for at least 70% of the days monitored.[11] Subjects who did not attend follow-ups were phoned and asked whether they had obtained their machines and if they had been using them.

Statistical Analysis

The data were entered into statistics software (SPSS, SPSS, Chicago, Illinois) and analyzed for frequency distributions. The chi-square test was used in the analysis of categorical variables. The Kolmogorov-Smirnov test was used to test normality of numerical variables. For normally distributed variables, the independent-samples *t* test was performed. For data not distributed normally, the Mann-Whitney U test was used. Statistical significance level was taken as $P < .05$. Logistic regression analysis was used to detect the factors affecting CPAP/BPAP adherence.

Results

In our sleep center 903 subjects were admitted for CPAP/BPAP titration and prescribed CPAP/BPAP; 255 of these refused to use CPAP/BPAP (Figure). The reasons for refusing CPAP/BPAP were the cost of the machine (90 subjects) and mask discomfort (165 subjects). Our study population consisted of 648 subjects who accepted to use CPAP/BPAP; 451 (69.6%) were male, 197 (30.4%) were female. The mean age was 51.2 ± 9.9 y, and the mean body mass index was 33.5 ± 6.5 kg/m^2. In the first night PSG the mean AHI was 54.1 ± 26.4 events/h, the mean apnea index was 31.4 ± 26.9 events/h, the mean oxygen desaturation index was 47 ± 2.9, and the mean lowest S_{pO_2} was 72.2 ± 13.5%. Two-hundred forty-eight (38.3%) of the 648 subjects attended follow-ups. A telephone call was made to 400 (61.7%) subjects who did not attend follow-ups, and 246 (37.9%) were reached, of whom 166 (25.6%) said that they had obtained the CPAP machine and had been using it, 80 (12.4%) said that they either had not obtained the machine or had not been using it. One-hundred fifty-four (23.7%) could not be reached. CPAP/BPAP adherence was 63.9% in a total of 414 subjects: 248 determined by follow-up visits, 166 by telephone call.

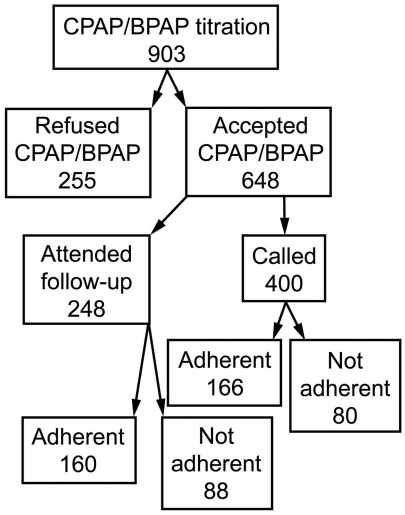

Figure. Flow chart. BPAP = bi-level positive airway pressure.

The analysis of adherence was performed for the 248 subjects who attended follow-up visits, and they were divided into adherent and non-adherent groups. Their subjective adherence was 85.1%, and their objective adherence was 64.5%. In 23.4% of these subjects their self-reports were essentially equal with the machine time on the counters (ie, ± 15 min per night); 30.6% used their machines for > 6 hours per night. The mean duration of CPAP/BPAP use was 16.5 ± 16.8 months. For the adherent and non-adherent groups, respectively, the mean hours per night and nights per week were 5.7 ± 1.2 h/night and 7 nights, and 3.2 ± 1.3 h/night and 5.1 ± 1.8 nights. Sex and body mass index were not significantly different between the groups. The adherent subjects were significantly younger ($P = .04$). ESS score decreased with CPAP/BPAP adherence in both groups, but this decrease was significantly higher in the adherent group ($P < .001$) (Table 1).

There were no significant differences between the groups in PSG findings, machine mode, CPAP/BPAP pressure (Table 2), comorbidities, history of ear/nose/throat opera-

Table 1. Demographics and Epworth Sleepiness Scale Scores of Subjects Who Attended Follow-up

	Adherent to CPAP (n = 160)	Not Adherent to CPAP (n = 88)	P
Age, mean ± SD y	50.4 ± 10.6	53.3 ± 9.6	.04
Sex			.22
Male, no. (%)	114 (71.2)	56 (63.6)	
Female, no. (%)	46 (28.8)	25 (36.4)	
Body mass index, mean ± SD kg/m^2	33.4 ± 6.6	33.6 ± 7.1	.85
ESS score before CPAP, mean ± SD	10.3 ± 5.8	10.9 ± 5.9	.45
ESS score after CPAP, mean ± SD	2.3 ± 2.8	4.6 ± 4.9	< .001
Percentage of subjects with a decreased ESS score	77.5	58	< .001

ESS = Epworth Sleepiness Scale

Table 2. First Night and Titration Night Polysomnography Findings, Modes, and Pressures of Subjects Who Attended Follow-up

	Adherent to CPAP (n = 160)	Not Adherent to CPAP (n = 88)	P
First polysomnography night			
Apnea-hypopnea index, events/h	54.1 ± 26.6	49.9 ± 27.8	.15
Oxygen desaturation index	46.6 ± 28.4	42.8 ± 25.9	.37
Lowest S_{pO_2}	71.7 ± 13.5	73.7 ± 12.8	.24
Periodic Limb Movement Index	20.2 ± 24.7	22.8 ± 24.2	.33
Sleep efficiency	79.6 ± 11.9	79.3 ± 12.3	.90
Sleep latency, min	20 ± 28.1	16.4 ± 14.9	.67
REM latency, min	155.5 ± 85.9	150.9 ± 100.9	.21
Titration night			
Apnea-hypopnea index, events/h	5.6 ± 5	5.2 ± 5.1	.27
Oxygen desaturation index	4 ± 5.2	4.3 ± 5.9	.93
Lowest S_{pO_2}	87.9 ± 6.8	86.7 ± 8.1	.21
Periodic Limb Movement Index	8 ± 11.3	11.5 ± 15.3	.12
Sleep efficiency	75.9 ± 12.4	77.3 ± 12.4	.37
Sleep latency, min	24 ± 23.3	21.5 ± 16.2	.76
REM latency, min	131.7 ± 95.2	128.7 ± 79.5	.87
CPAP mode, %	85	84	.85
BPAP mode, %	15	16	.77
Pressure, cm H_2O	10.6 ± 2	10.6 ± 2.1	.93

Values are mean ± SD, except for CPAP mode and BPAP mode.
REM = rapid eye movement
BPAP = bi-level positive airway pressure

tions, machine mode (BPAP vs CPAP), mask type (nasal or oronasal), or presence of built-in heated humidifier.

The incidence of adverse effects related to the mask (air leak, skin abrasions and ulcerations, teeth and jaw ache, and morning headache) was not significantly different between the groups. Rhinitis symptoms were more frequent in the non-adherent (67.4% vs 47.4%), but that difference is not statistically significant (P = .08). Dry mouth and nose occurred in 62.5% of the adherent group and 70% of the non-adherent group (P = .23). Chest discomfort, sleep disturbances, and difficulty in falling asleep were significantly higher in the non-adherent group (all P < .01) (Table 3).

The subjects were also questioned about whether they had satisfactory sleep after they started to use CPAP/BPAP; 91.9% of the adherent subjects and 72.6% of the non-adherent subjects said that they did (P < .001).

Multivariate logistic regression analysis revealed that the differences with respect to chest discomfort, ESS score, and difficulty in falling asleep were statistically

Table 3. Adverse Effects of CPAP in Subjects Who Attended Follow-up

	Percentage		
	Adherent to CPAP (n = 160)	Not Adherent to CPAP (n = 88)	P
Difficulty falling asleep	18.1	38.1	.001
Sleep disturbances	26.9	50.6	< .001
Chest discomfort	10.6	22.6	.01
Machine noise	31.9	41	.16
Air leak	36.3	45.8	.15
Skin abrasions and ulcerations	19.4	20.2	.87
Dry mouth or nose	56.3	64.3	.23
Tooth or jaw pain	5.6	9.6	.25
Rhinitis symptoms	5.6	12	.08
Morning headache	17.5	26.2	.11

significant, whereas no significant relationship was de tected for rhinitis symptoms (P = .009, < .001, .001, and .61, respectively)

Discussion

Our results show that of 903 subjects referred for a sleep study, only 248 continued to follow up for treatment and were adherent to CPAP. At best, including subjects reached only by telephone, 248 + 166 = 414/903 used CPAP after a PSG diagnosis of OSA was made. The primary end point of our study is the low percentage (38.3%) of subjects who came for follow-up. The subjects who were prescribed CPAP/BPAP were asked to come to follow-up visits after 1 month, and those who did not attend follow-ups were called; however, just 38.3% of the subjects came for controls. The low ratio of the subjects who attended follow-ups may have been due to the low social and economic status of the subjects, and the fact that they did not care about their diseases. It is probable that our subjects belonged to a different population, compared to previous studies. One of the important reasons for not using the machine may have been the requirement to pay some amount of money, due to insurance problems. One other reason could have been that sleeping bound to a machine was bothersome and uncomfortable for the vast majority of subjects. Another major finding of the study was that objective adherence was much lower than subjective adherence. The adherent subjects were younger. Improving of ESS score and having satisfactory sleep are correlated significantly with adherence. Chest discomfort, difficulty falling asleep, and sleep disturbances were significantly higher in non-adherent subjects.

In the absence of a standardized scale for adherence, the Kribbs et al definition of adherence as ≥ 4 hours per night for at least 70% of the days monitored has been used in many studies,[11,12,22] which is also the case in our study. In the Kribbs et al study, subjective adherence was 60% and objective adherence was 46%. In addition to studies conducted to assess only objective adherence or subjective adherence,[22] there have been studies to compare subjective and objective adherence. In these studies, subjective adherence was higher,[23] as in the Kribbs et al study, or subjective and objective adherence were similar.[24] In our study, 23.4% of the subjects who attended follow-up had been using CPAP/BPAP as they reported. In our subjects who attended follow-ups, subjective adherence was 85.1% and objective adherence was 64.5%. Adherence due to duration of usage was detected in subjects who attended follow-ups, so, considering the whole group, 38.3% of the subjects were followed and objective adherence was calculated for this small group of subjects. This may be considered a limitation of our study.

Although the Kribbs et al definition of adherence has been used in many studies, recent studies have reported that CPAP use for > 6 hours more significantly improved memory performance and daytime sleepiness. In those studies, CPAP use for > 6 hours was 45.1%[13] and 32.7%.[14] Similarly, in our study this value was 30.6% among those who attended follow-ups.

In the study of Sin et al,[25] adherence was higher in older subjects and women. In our study the adherent subjects were significantly younger than the non-adherent subjects. This might be due to the fact that young patients take their disease more seriously and realize that adherence results in positive changes in their daily life, including work performance. Sex and body mass index were not significantly different between the adherent and non-adherent subjects. Comorbidities and previous ear/nose/throat operations also did not affect adherence.

In the Drake et al study[24] the most important factor that affected adherence was an increase in sleep efficiency in the titration night PSG, compared to the first night PSG. In most studies,[26-29] the AHI values in the first night PSG were significantly higher in subjects who had been using CPAP/BPAP, and it was interpreted that CPAP adherence was closely related to disease severity. On the other hand, there are also studies[30-32] demonstrating no correlation between CPAP adherence and AHI. In our study no difference was found between adherent and non-adherent subjects in PSG findings; it was interpreted that disease severity did not affect adherence.

In CPAP/BPAP adherence studies,[33-35] the machine mode has been thought to affect adherence. We found that the percentages of subjects using BPAP in the adherent and non-adherent groups were similar (15% and 16%, respectively), so we conclude that machine mode did not affect adherence. In the Kribbs et al study,[11] the pressure level did not affect adherence. In our study, the mean

pressures were similar in the 2 groups, so we found that the pressure level did not affect adherence. Nasal masks are better tolerated than oronasal masks. In the Mortimore et al study,[36] adherence was higher in subjects using nasal mask, but in other studies,[37] including ours, mask type did not affect adherence.

There are various reports regarding the effect of heated humidification on adherence. While in some studies heated humidification increased adherence, in other studies it did not affect adherence, but in all those studies heated humidification increased patient comfort.[22] In the Mador et al study,[38] heated humidification did not increase adherence but did decrease adverse effects such as dry mouth or nose. We found that heated humidification did not affect adherence.

In most of the studies, improvement in daytime sleepiness and quality of life were considered when assessing adherence. Although a few studies reported that ESS score had no relationship to adherence, most of the studies found a significant reduction in ESS score with CPAP, and that the most important factor that increased adherence was amelioration of daytime sleepiness.[22,23-25] In our study we found no pre-CPAP difference in ESS scores between the adherent and non-adherent subjects. After CPAP initiation though, 77.5% of the adherent subjects' ESS scores were reduced. This reduction was significantly higher than that in the non-adherent subjects. In addition, the adherent subjects stated that they woke up significantly better rested than the non-adherent subjects.

Adverse effects decrease CPAP adherence significantly. These adverse effects include chest discomfort, anxiety, difficulty falling asleep, sleep disturbances, air leakage, skin abrasions and ulcerations, dry mouth and nose, rhinitis, rhinorhea, sinusitis, headaches, pressure intolerance, teeth and jaw ache, noise, and smell related to the machine.[22] In our study, dry mouth and nose were common in both groups. Previous studies stated that skin and mask problems were the most important factors affecting adherence,[5,9] but this was not the case in our study, which might be because some of our subjects who had problems with the mask or skin abrasions did not attend the follow-ups. Chest discomfort, difficulty falling asleep, and sleep disturbances were significantly more common in the non-adherent group.

A large survey on management of OSAS demonstrated that nasal congestion increased the likelihood of discontinuing CPAP/BPAP, whereas medications for nasal congestion improved adherence.[39] In our study the symptoms of rhinitis were also more common in the non-adherent group, but the difference was not significant. The subjects with nasal symptoms were prescribed nasal steroids, and we believe this improved adherence.

Conclusions

Despite their being called many times, only 38.3% of the subjects attended the follow-ups. The low socio-economic status of our population and unawareness of the seriousness of the disease might contribute to this fact. We conclude that when CPAP/BPAP is prescribed, instructive visual materials should be used. Other important conclusions are that objective adherence was lower than subjective adherence, younger subjects were more adherent, and the most important factors that correlate with adherence were substantial improvement of daytime sleepiness and the effect of CPAP/BPAP on satisfactory sleep. In non-adherent subjects the most important adverse effects were chest discomfort, difficulty falling asleep, and sleep disturbances. Patients should be strongly encouraged to attend follow-ups, objective adherence should be monitored, and it should be emphasized that sleep quality and daytime hypersomnolence will improve with CPAP/BPAP use.

ACKNOWLEDGMENTS

We are grateful to Mustafa Tasdemir for statistical analysis.

REFERENCES

1. Partinen M, Hublin C. Epidemiology of sleep disorders. In: Kryger MH, Roth T, Dement WC, editors. Principles and practice of sleep medicine, 4th edition. Philadelphia: Elsevier; 2005:626-647.
2. Young T, Palta M, Dempsey J, Skatrud J, Weber S, Badr S. The occurrence of sleep-disordered breathing among middle-aged adults. N Engl J Med 1993;328(17):1230-1235.
3. Philips BA, Berry DT, Schmitt FA, Harbison L, Lipke-Molby T. Sleep-disordered breathing in healthy aged persons: two and three-year follow-up. Sleep 1994;17(5):411-415.
4. Sullivan CE, Berthon-Jones M, Issa FG, Eves L. Reversal of obstructive sleep apnoea by continuous positive airway pressure applied through the nares. Lancet 1981;317(8225):862-865.
5. Grunstein R. Continuous positive airway pressure treatment for obstructive sleep apnea-hypopnea syndrome. In: Kryger MH, Roth T, Dement WC, editors. Principles and practice of sleep medicine, 4th edition. Philadelphia: Elsevier; 2005:1066-1080.
6. Engleman HM, Martin SE, Kingshott RN, Mackay TW, Deary IJ, Douglas NJ. Randomised placebo controlled trial of daytime function after continuous positive airway pressure (CPAP) therapy fort the sleep apnoea/hypopnoea syndrome. Thorax 1998;53(5):341-345.
7. Chokroverty S. Editor's corner. Sleep Med 2000;1(3):173.
8. Strollo PJ, Sanders MH, Atwood CW. Positive pressure therapy. Clin Chest Med 1998;19(1):55-68.
9. Berry RB. Improving CPAP compliance: man more than machine. Sleep Med 2000;1(3):175-178.
10. Hoy CJ, Vennelle M, Kingshott RN, Engleman HM, Douglas NJ. Can intensive support improve continuous positive airway pressure use in patients with the sleep apnea/hypopnea syndrome? Am J Respir Crit Care Med 1999;159(2):1096-1100.
11. 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(4):887-895.

12. Weaver TE, Grustein RR. Adherence to continuous positive airway pressure therapy: the challenge to effective treatment. Proc Am Thorac Soc 2008;5(2):173.
13. Weaver TE, Mailsin G, Dinges DF, Bloxham T, George CF, Greenberg H, et al. Relationship between hours of CPAP use and achieving normal levels of sleepiness and daily functioning. Sleep 2007;30(6): 711-719.
14. Zimmerman ME, Arnedt T, Stanchina M, Millman RP, Aloia MS. Normalization of memory performance and positive airway pressure adherence in memory-impaired patients with obstructive sleep apnea. Chest 2006;130(6):1772-1778.
15. Johns MW. A new method for measuring daytime sleepiness scale. Sleep 1991;14(6):540-545.
16. Rechtschaffen A, Kales A, editors. A manual of standardized terminology, techniques and scoring system for sleep stages of human subjects. Los Angeles: Brain Information Service/Brain Research Institute; 1968.
17. Iber C, Ancoli-Israel S, Chesson AL, Quan SF. The AASM manual for the scoring of sleep and associated events. rules, terminology and technical specifications. Westchester, IL: American Academy of Sleep Medicine; 2007.
18. The Report of an American Academy of Sleep Medicine Task Force. Sleep-related breathing disorders in adults: recommendations for syndrome definition and measurement techniques in clinical research. Sleep 1999;22(5):667-689.
19. American Academy of Sleep Medicine. International classification of sleep disorders, 2nd edition. Diagnostic and coding manual. Westchester, IL: AASM; 2005.
20. Littner M, Hirshkowitz M, Davila D, Anderson WM, Kushida CA, Woodson BT, et al; Standards of Practice Committee of the American Academy of Sleep Medicine. Practice parameters for the use of auto-titrating continuous positive airway pressure devices for titrating pressures and treating adult patients with obstructive sleep apnea syndrome. Sleep 2002;25(2):143-147.
21. Task Force of the American Academy of Sleep Medicine. Clinical guidelines for the manual titration of positive airway pressure in patients with obstructive sleep apnea. Positive airway pressure titration. J Clin Sleep Med 2008;4(2):157-171.
22. Gay P, Weaver T, Loube D, Conrad I. Evaluation of positive airway pressure treatment for sleep related breathing disorders in adults. A review by the Positive Airway Pressure Task Force of the Standards of Practice Committee of the American Academy of Sleep Medicine. Sleep 2006;29(3):381-401.
23. Hui DS, Choy DK, Li TS, Ko FW, Wong KK, Chan JK, Lai CK. Determinants of continuous positive airway pressure compliance in a group of Chinese patients with obstructive sleep apnea. Chest 2001;120(1):170-176.
24. Drake CL, Day R, Hudgel D, Stefadu Y, Parks M, Syron ML, Roth T. Sleep during titration predicts continuous positive airway pressure compliance. Sleep 2003;26(3):308-311.
25. Sin DD, Mayers I, Man GCW, Pawluk L. Long-term compliance rates to continuous positive airway pressure in obstructive sleep apnea: a population-based study. Chest 2002;121(2):430-435.
26. Popescu G, Latham M, Allgar V, Elliott MW. Continuous positive airway pressure for sleep apnoea/hypopnoea syndrome: usefulness of a 2-week trial to identify factors associated with long-term use. Thorax 2001;56(9):727-733.
27. Yetkin O, Kunter E, Gunen H. CPAP compliance in patients with obstructive sleep apnea syndrome. Sleep Breath 2008;12(4):365-367.
28. 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 Crit Care Med 1999;159(4 Pt 1):1108-1114.
29. Stepnowsky CJ, Dimsdale JE. Dose-response relationship between CPAP compliance and measures of sleep apnea severity. Sleep Med 2002;3(4):329-334.
30. Engleman HM, Kingshott RN, Wraith PK, Mackay TW, Deary IJ, Douglas NJ. Randomized placebo-controlled crossover trial of continuous positive airway pressure for mild sleep apnea/hypopnea syndrome. Am J Respir Crit Care Med 1999;159(2):461-467.
31. Engleman HM, Martin SE, Douglas NJ. Compliance with CPAP therapy in patients with the sleep apnoea/hypopnoea syndrome. Thorax 1994;49(3):263-266.
32. Pépin JL, Krieger J, Rodenstein AC, Cornette A, Sforza E, Delguste P, et al. Effective compliance during the first 3 months of continuous positive airway pressure. A European prospective study of 121 patients. Am J Respir Crit Care Med 1999;160(4):1124-1129.
33. Reeves-Hoché MK, Hudgel DW, Meck R, Witteman R, Ross A, Zwillich CW. Continuous versus bilevel positive airway pressure for obstructive sleep apnoea. Am J Respir Crit Care Med 1995;151 (2 Pt 1):443-449.
34. Gay PC, Herold DL, Olson EJ. A randomized, double-blind clinical trial comparing continuous positive airway pressure with a novel bilevel pressure system for treatment of obstructive sleep apnea syndrome. Sleep 2003;26(7):864-869.
35. Schäfer H, Ewig S, Hasper E, Lüderitz B. Failure of CPAP therapy in obstructive sleep apnoea syndrome: predictive factors and treatment with bilevel-positive airway pressure. Respir Med 1998;92(2): 820-827.
36. Mortimore IL, Whittle AT, Douglas NJ. Comparison of nose and face mask CPAP therapy for sleep apnoea. Thorax 1998;53(4):290-292.
37. Anderson FE, Kingshott RN, Taylor DR, Jones DR, Kline LR, Whyte KF. A randomized crossover efficacy trial of oral CPAP (Oracle) compared with nasal CPAP in the management of obstructive sleep apnea. Sleep 2003;26(6):721-726.
38. Mador MJ, Krauza M, Pervez A, Pierce D, Braun M. Effect of heated humidification on compliance and quality of life in patients with sleep-apnea using nasal continuous positive airway pressure. Chest 2005;128(4):2151-2158.
39. Parthasarathy S, Haynes PL, Budhiraja R, Habib MP, Quan SF. A national survey of the effect of sleep medicine specialists and American Academy of Sleep Medicine: accreditation on management of obstructive sleep apnea. J Clin Sleep Med 2006;15:2(2): 133-142.