Original Article

In patients with minimally symptomatic OSA can baseline characteristics and early patterns of CPAP usage predict those who are likely to be longer-term users of CPAP

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Background: Long-term continuous positive airway pressure (CPAP) usage varies between individuals. It would be of value to be able to identify those who are likely to benefit from CPAP (and use it long term), versus those who would not, and might therefore benefit from additional help early on. First, we explored whether baseline characteristics predicted CPAP usage in minimally symptomatic obstructive sleep apnoea (OSA) patients, a group who would be expected to have low usage. Second, we explored if early CPAP usage was predictive of longer-term usage, as has been shown in more symptomatic OSA patients.

Methods: The MOSAIC trial was a multi-centre randomised controlled trial where minimally symptomatic OSA patients were randomised to CPAP, or standard care, for 6 months. Here we have studied only those patients randomised to CPAP treatment. Baseline characteristics including symptoms, questionnaires [including the Epworth sleepiness score (ESS)] and sleep study parameters were recorded. CPAP usage was recorded at 2–4 weeks after initiation and after 6 months. The correlation and association between baseline characteristics and 6 months CPAP usage was assessed, as was the correlation between 2 and 4 weeks CPAP usage and 6 months CPAP usage.

Results: One hundred and ninety-five patients randomised to CPAP therapy had median [interquartile range (IQR)] CPAP usage of 2:49 (0:44, 5:13) h:min/night (h/n) at the 2–4 weeks visit, and 2:17 (0:08, 4:54) h/n at the 6 months follow-up visit. Only male gender was associated with increased long-term CPAP use (male usage 2:56 h/n, female 1:57 h/n; P=0.02). There was a moderate correlation between the usage of CPAP at 2–4 weeks and 6 months, with about 50% of the variability in long-term use being predicted by the short-term use.

Conclusions: In patients with minimally symptomatic OSA, our study has shown that male gender (and not OSA severity or symptom burden) is associated with increased long-term use of CPAP at 6 months. Although, in general, early patterns of CPAP usage predicted longer term use, there are patients in whom this is not the case, and patients with low initial usage may need to extend their CPAP trial before a decision about longer-term use is made.

Keywords: Obstructive sleep apnoea (OSA); continuous positive airway pressure (CPAP); patient compliance

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Introduction

Continuous positive airway pressure (CPAP) usage is variable in obstructive sleep apnoea (OSA). Large scale trials of CPAP for patients recruited based on cardiovascular risk, who are generally less sleepy, have shown particularly low usage (1). This may be due to patients not perceiving benefit from CPAP, as they are usually not very sleepy.

In a previous study, severity of OSA, measured by the oxygen desaturation index (ODI) >4%, was predictive of CPAP compliance (2). This work looked at patients with OSA from the sleep clinic who mainly had classical symptoms of excessive daytime somnolence (EDS). It is interesting to note that in this previous paper, symptoms, particularly as measured by the Epworth sleepiness score (ESS), were not predictive of long-term CPAP compliance.

In patients with OSA and EDS, CPAP treatment not only improves symptoms, but it also reduces blood pressure (3). However, a recent meta-analysis (4), in minimally symptomatic patients, also showed that CPAP treatment did, on average, reduce daytime somnolence compared to controls, but only improved diastolic blood pressure in patients who used CPAP for ≥4 h/night. Predicting long-term CPAP usage in minimally symptomatic OSA patients would be useful to identify patients most likely to benefit from therapy.

In this current study: first, we aimed to see if the relationship between ODI and CPAP usage found in our earlier work could be verified in a population of minimally symptomatic patients and whether any other baseline characteristics predicted long-term CPAP usage; second, we aimed to see if early patterns of CPAP usage were predictive of usage at 6 months, to test the validity of using only a short trial of CPAP to determine longer-term use.

Methods

The MOSAIC trial

The MOSAIC trial was a multicentre randomised, parallel, 6-month controlled trial that was conducted between May 2006 and February 2010. The trial was approved by the ethics committees of all the centres (REC No: 05/Q1604/159) and registered (ISRCTN 34164388).

Patients were randomized to 6 months of CPAP, or standard care, if they had an ODI of >7.5 events/h due to OSA on a baseline sleep study, but the enrolling physician and patient felt they had insufficient daytime symptoms to mandate CPAP treatment. The full protocol has been published previously (5).

In this current study we assessed only the patients randomised to CPAP in the MOSAIC trial. First, we investigated the association of baseline characteristics with 6 months CPAP usage. Second, we explored the correlation between 2 and 4 weeks usage of CPAP and 6 months usage.

Baseline characteristics

Patient demographics, symptoms, ODI, ESS, Sleep Apnoea Quality of Life Index (SAQLI), short form-36 physical (SF-36 PCS) and mental (SF-36 MCS) summary scores, and maintenance of wakefulness test equivalent (OSLER test) (6) were assessed. After enrolment but before randomisation, overnight pulse oximetry was repeated with the same oximeters (Minolta) across all centres for uniformity of trial ODI.

CPAP usage

Patients were invited to follow-up between 2 and 4 weeks, and 6 months after randomisation. Data was analysed regardless of exactly when they attended these trial appointments. CPAP usage was assessed at the 2–4 weeks and the 6 months visits. Study withdrawals were assigned 0:00 h:min/night (h/n) in the analyses.

At 2–4 weeks follow-up, all nights were analysed where available and a mean nightly usage calculated.

We defined long-term usage at 6 months follow-up in two ways. In method 1, all nights between the 2–4 weeks and 6 months follow-up were analysed when available, and a mean 6-month usage calculated. In method 2, the average CPAP usage was recorded over the shorter period of 1 week prior to the 6 months follow-up.

Method 2 was thought most likely to reflect longer-term CPAP usage beyond 6 months. Method 2 however, runs the risk of not necessarily being fully representative due to short term differences such as a holiday, or an upper respiratory tract infection.

Patient willingness to continue CPAP

To explore a different aspect of CPAP acceptance in this minimally symptomatic group, patients were asked at the 6 months follow-up whether they were prepared to continue CPAP beyond the 6 months trial period. Study withdrawals and those with missing data were assumed to have been unwilling to continue CPAP.

Table 1 Baseline characteristics for male patients, female patients and all patients

Variable	Mean (SD), median (IQR) or number (%)		
	Male	Female	All patients
Number (%)	153 (78.5)	42 (21.5)	195 (100.0)
Age, median years [IQR]	58 [51, 63]	60 [51, 65]	59 [51, 63]
Ethnicity, number white (%)	148 (96.7)	40 (95.2)	188 (96.4)
BMI, median kg/m^2 (IQR)	31.1 (28.7, 33.8)	30.9 (27.6, 36.9)	31.1 (28.0, 34.4)
Smoking status, number (%)			
Current	15 (9.8)	2 (4.8)	17 (8.7)
Ex-smoker	87 (56.9)	15 (35.7)	102 (52.3)
Never smoker	51 (33.3)	25 (59.5)	76 (39.0)
Reported snoring, number yes (%)	149 (97.4)	41 (97.6)	190 (97.4)
Reported apneas, number yes (%)	116 (75.8)	26 (61.9)	142 (72.8)
Reported choking, number yes (%)	52 (34.0)	14 (33.3)	66 (33.8)
Reported nocturia, number yes (%)	85 (55.6)	29 (69.0)	114 (58.5)
ODI, median (IQR)	10.3 (4.6, 18.7)	9.6 (5.1, 14.7)	10.2 (4.7, 17.5)
ESS, median [IQR]	8 [4, 11]	9 [2, 12]	8 [4, 11]
SAQLI, median (IQR)	4.9 (4.1, 5.9)	4.9 (3.7, 5.8)	4.9 (4.0, 5.9)
SF-36 physical summary, median (IQR)	45.3 (33.6, 51.8)	39.1 (33.1, 49.8)	44.8 (33.6, 51.6)
SF- 36 mental summary, median (IQR)	50.9 (41.1, 57.0)	48.2 (39.6, 55.9)	50.5 (40.5, 56.6)
OSLER, median seconds (IQR)	2,400 (1,799, 2,400)	2,400 (1,169, 2,400)	2,400 (1,680, 2,400)

SD, standard deviation; IQR, interquartile range; BMI, body mass index; ODI, oxygen desaturation index; ESS, Epworth sleepiness score; SAQLI, Sleep Apnoea Quality of Life Index; SF-36, short form-36; OSLER, Oxford sleep latency test.

Statistical analysis

Statistical analysis was performed using IBM SPSS software, version 20. Baseline characteristics were compared to 6 months usage data using *t*-tests or one way ANOVA (categorical variables), and univariable linear regression (continuous variables) with assumption of normality of the samples means due to the large sample size (central limits theorem). Correlation between variables was also assessed using Pearson's correlation coefficient.

Multivariable regression was performed for all baseline characteristics as the independent predictors and with the 6 months CPAP usage as the dependant variable in a stepwise backwards model (variables with P>0.10 removed) and separately with a stepwise forward model (variables with P<0.05 included).

Separately 2–4 weeks follow-up CPAP usage was compared to 6 months CPAP usage data with Pearson's correlation.

Results

One hundred and ninety-five patients were randomised to receive CPAP during the MOSAIC trial. The baseline characteristics for these patients are shown in *Table 1*.

One hundred and eighty-eight patients attended 2–4 weeks follow-up and median time to follow-up was 21 days (interquartile range or IQR 15 to 28), 183 patients attended their 6 months follow-up, median time to follow-up was 195 days (IQR 182 to 210).

Usage

The median (IQR) of the mean daily CPAP usage was 2:49 (0:44, 5:13) h/n at the 2–4 weeks visit. It was 2:17 (0:08, 4:54) h/n at the 6 months follow-up visit (method 1) and 2:12 (0:00, 5:27) h/n in the week prior to 6 months follow-up visit (method 2). Forty (21%) patients had either stopped CPAP treatment at 6 months follow-up or did not attend follow-up.

Table 2 Comparison of CPAP usage and continuous variables

Continuous variables	B (unstandardized), h/night	Pearson's correlation coefficient	P
Age (years)	−0.01	−0.04	0.59
BMI (kg/m^2)	−0.03	−0.06	0.37
ODI (events/hour)	0.007	0.04	0.59
ESS	−0.04	−0.06	0.38
SAQLI	0.14	0.07	0.37
SF-36 physical summary	0.004	0.02	0.79
SF-36 mental summary	0.02	0.07	0.32
OSLER (s)	0.000	−0.05	0.53

The association between continuous variables and mean CPAP usage at 6 months (method 1) was assessed using univariable linear regression (B) and correlation was assessed using Pearson's correlation coefficient. CPAP, continuous positive airway pressure; BMI, body mass index; ODI, oxygen desaturation index >4%; ESS, Epworth sleepiness score; SAQLI, Sleep Apnoea Quality of Life Index; SF-36, short form 36; OSLER, Oxford sleep latency test.

Table 3 Comparison of CPAP usage and categorical variables

Categorical variables	Mean (SD)	N	95% CI	P
Snoring			−0:21, 4:00	0.06
Yes	2:40 (2:27)	190		
No	4:30 (1:37)	5		
Apnoeas			−1:19, 0:16	0.19
Yes	2:51 (2:26)	142		
No	2:20 (2:29)	51		
Choking			−0:05, 1:22	0.08
Yes	2:18 (2:21)	66		
No	2:56 (2:28)	129		
Nocturia			−0:30, 0:55	0.56
Yes	2:37 (2:31)	114		
No	2:50 (2:22)	79		
Gender			−1:49, −0:09	0.02*
Male	2:56 (2:29)	153		
Female	1:57 (2:11)	42		
Ethnicity			−2:29, 1:14	0.50
White	2:45 (2:28)	188		
Non-White	2:07 (1:55)	7		
Smoking status			/	0.26
Never smoker	2:52 (2:27)	76		
Ex-smoker	2:46 (2:28)	102		
Current smoker	1:48 (2:14)	17		

For categorical variables the differences in mean CPAP usage at 6 months (method 1) were compared using unpaired *t*-tests. For smoking status differences between groups in mean CPAP usage at 6 months (method 1) were compared with a one way ANOVA. *, P<0.05. CPAP, continuous positive airway pressure; SD, standard deviation; 95% CI, 95% confidence intervals of difference in means between groups.

Baseline characteristics and 6 months CPAP usage (method 1)

Mean CPAP usage at 6 months was significantly greater in male participants [mean daily male usage 2:56 h/n, female 1:57 h/n; 95% confidence interval (CI) −1:49, −0:09 h/n, P=0.02]. For all other categorical variables there were no other significant effects on CPAP usage. None of the baseline characteristics that were continuous variables were significantly associated with CPAP usage at 6 months (*Tables 2,3*).

Using a stepwise backwards multivariable linear regression, male gender (unstandardized B =1:02 h/n, P=0.02) was associated with increased CPAP usage at 6 months follow-up. In stepwise forwards multivariable linear regression male gender remained the only variable significantly associated with CPAP usage at 6 months. In both models gender only explained a small amount of the variance in CPAP usage (r^2=0.03).

Baseline characteristics and 6 months CPAP usage (method 2)

In method 2 analyses, using only this last week of usage data, body mass index (BMI) was associated with increased long-term CPAP use (unstandardized B =−0:04 h/n per 1 kg/m^2 increase in BMI, r=−0.15, P=0.04) and male gender was associated with increased long-term CPAP use (male mean usage =3:02 h/n, female =1:56 h/n, P=0.01). No other baseline characteristics were significantly associated with long-term CPAP usage. Forwards multivariable analysis selected gender (r^2=0.03) and backwards multivariable analysis selected both gender and BMI (r^2=0.04), and suggested gender is dominant, but it still explained very little of the variance.

Two to four weeks usage and 6 months CPAP usage

Average hours of usage of CPAP at the 2–4 weeks follow-up was correlated with the average CPAP usage at 6 months

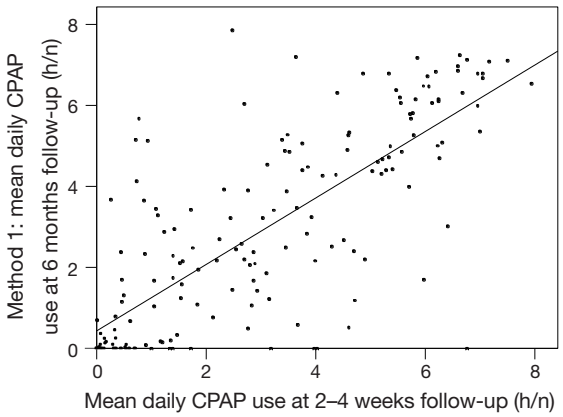

Figure 1 Correlation between mean daily CPAP use at 2–4 weeks follow-up and 6 months follow-up (method 1, r=0.77, P<0.001). CPAP, continuous positive airway pressure; h/n, hours/night.

follow-up (method 1: r=0.77, r^2=0.60, P<0.001, *Figure 1*. Method 2: r=0.65, r^2=0.42, P<0.001).

Willingness to continue CPAP

One hundred and thirty-eight patients (70.8%) were prepared to continue CPAP beyond the 6 months follow-up. Despite declaring a preparedness to continue CPAP, 41 of these 138 patients (30%) had used CPAP for less than 2:00 h/n.

Discussion

In patients with minimally symptomatic OSA the baseline characteristic most associated with increased CPAP usage at 6 months was male gender. There was only a moderate correlation between 2 and 4 weeks usage of CPAP and 6 months usage; approximately 50% of the variance in long-term use being predicted by the short term use.

Gender differences have been reported previously, with higher CPAP usage in male patients (2,7,8). Only 42 of our participants were female, but our finding of higher male CPAP use supports a similar gender difference in CPAP usage for this minimally symptomatic group. This difference was not explained by sleep apnoea severity or differing symptoms between males and females. ODI and symptoms (ESS, SAQLI, SF-36) were similar in males and females at baseline, and did not show a significant contribution in the regression analysis.

Previously our unit conducted a large study of 639 patients initiated on CPAP (2). ODI was significantly correlated with CPAP adherence, but ESS was not. Elsewhere ESS alone was linked to CPAP usage (1), and in contrast Somiah *et al.* (9) found neither were correlated to CPAP usage. In this trial of patients with minimally symptomatic OSA we were not able to reproduce data showing either OSA severity (ODI) or ESS to be significant indicators of long-term CPAP usage.

The reasons why baseline ESS, ODI or other factors have not been consistently predictive of CPAP usage are not clear. It may be that we are simply not currently measuring at baseline the critical factors that determine CPAP usage; for example patient personality or other unmeasured consequences of sleep fragmentation. A second possibility is that a given ESS score is unlikely to indicate the same degree of sleepiness in different individuals, as people perceive the score differently. Supporting this concept, is the fact that the reduction in ESS, from baseline to 6 months, was associated with 6 months average CPAP usage (method 1; unstandardized B =0:14 h/n per 1 point increase in ESS, r=0.30, P<0.001), suggesting that the change in ESS following treatment may be more representative of the effects of OSA on an individual than the absolute value at baseline.

Patterns of CPAP usage have been shown to be established as early as the 4th night of CPAP use (10). We too have found in general that levels of CPAP usage are established early, with usage of CPAP at 2–4 weeks being moderately correlated to 6 months usage. However, a 2–4 weeks trial of CPAP for some is probably too short, as a significant minority (15 of 113 patients; 13%) who used CPAP <4 h/n at 2–4 weeks nonetheless went on to use CPAP for >4 h/n at the 6 months follow-up (method 1). Identifying low usage early may give clinicians an opportunity to improve usage, rather than being regarded as an indication of poor response.

Our analysis of usage in the last week prior to 6 months follow-up (method 2) was performed as this might be more representative of long-term usage, rather than the 6 months average following the first follow-up appointment (method 1). Usage was very similar in this last week compared to the whole 6 months average. In method 1, the median usage was 2:17 h/n, compared to 2:12 h/n in method 2 analysis (r=0.80, P<0.001). Both analyses showed that male gender was the baseline characteristic most strongly associated with increased longer-term CPAP usage.

Willingness to continue CPAP is often thought of as indicative of actual continuing CPAP usage. However, we found that many patients prepared to continue CPAP were in fact only using CPAP for 2 h or less a night (30%).

Patients may only use CPAP on single nights prior to important events, such as driving long distances, and they may have significant personal benefit from CPAP below the current thresholds (non-evidence-based) currently used to define 'adequate' compliance (11).

Conclusions

Despite CPAP being of overall benefit in patients with minimally symptomatic OSA, this study has shown that male gender was associated with increased long-term CPAP usage at 6 months, and not ESS or ODI. Gender accounted for very little of the variation in CPAP usage at 6 months. Furthermore, this study supports research suggesting that patterns of CPAP usage are established early, although they can change in a clinically significant minority. One month may be too short a length of trial to determine patients likely to benefit from CPAP therapy in the longer term.

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Footnote

Conflicts of Interest: JR Stradling has done some consulting work for ResMed (Abingdon, UK). No other authors have any conflicts of interest to declare.

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