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Long-term treatment with continuous positive airway pressure improves quality of life in obstructive sleep apnoea syndrome

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ABSTRACT: Continuous positive airway pressure (CPAP) is an established treatment of obstructive sleep apnoea syndrome (OSAS). While it is known that CPAP reverses the pathological breathing pattern and improves daytime sleepiness, there are no sufficient data on the long-term influence of CPAP on quality of life in patients with OSAS.

Thirty-nine patients with polysomnographically verified OSAS (apnoea/hypopnoea index (AHI): (mean±SD) 46.8±21.8 events·h^{-1}) were prospectively studied. All patients answered three quality of life measures (Complaint List, Nottingham Health Profile Part 1 (NHP), and Verbal Analogue-Scale "quality of life") prior to the initiation of CPAP therapy. After a mean of 9 months they were re-evaluated by polysomnography, and completed the questionnaires once again.

As expected, CPAP was effective in treating the sleep-related breathing disorder. AHI decreased significantly from (mean±SD) 46.8±21.8 events·h^{-1} to 3.3±6.3 events·h^{-1}, and minimum oxygen saturation increased from 77.1±9.3% to 89.9±3.4%, while body mass index did not change significantly (31.3±5.4 *versus* 30.8±4.8 kg·m^{-2}). During long-term treatment with CPAP the Complaint List revealed a significant improvement of the extent of subjective impairment due to physical and general complaints (26.4±9.9 *versus* 20.4±11.1), and NHP a significant improvement of emotional reactions (19.8±21.7 *versus* 11.1±14.0) and energy (50.8±36.6 *versus* 32.1±36.7), but not of pain, physical mobility, sleep, social isolation, and quality of life as assessed by the Verbal Analogue-Scale.

It is concluded that long-term continuous positive airway pressure therapy is effective in improving not only pathological breathing patterns but also parameters that estimate quality of life in patients with obstructive sleep apnoea syndrome.
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Obstructive sleep apnoea syndrome (OSAS) is a common health burden: it is estimated that at least 2% of females and 4% of males meet the minimal diagnostic criteria for this sleep-related breathing disorder [1]. It is associated with cardiovascular disease, such as hypertension [2, 3] pulmonary hypertension [4, 5], myocardial infarction [6], or stroke [7]. Furthermore, patients with OSAS suffer from decreased daytime performance [8].

In 1981 continuous positive airway pressure (CPAP) was introduced for treatment of OSAS [9] and it could be shown that respiration may normalize while using the device although, lately, some debate has arisen about the beneficial effects of CPAP [10].

Quality of life issues have become steadily more important and there has been an almost exponential increase in the use of quality of life evaluation as a technique of clinical research and in defining disease activity and response to treatment [11]. So far, data about the effect of CPAP on quality of life in patients with OSAS are limited [12–19], and there are only few prospective data on long-term effects.

The authors therefore attempted to determine quality of life with the help of three quality of life measures at baseline and after 9 months of CPAP therapy in patients with OSAS. Since different quality of life scales measure different aspects of health decrement and it is not clear which of the standard measures is most suited to measuring the health gain from CPAP, the authors were interested to see how three different scales perform in this situation.

Patients and methods

Subjects were recruited from consecutive patients referred to the authors' sleep laboratory (Dept of Medicine I, Ruhr University Bochum, Marienhospital, Herne, Germany) for snoring, suspected OSAS, or excessive daytime sleepiness. Enrolment criteria were: 1) a polysomnographically verified OSAS (apnoea/hypopnoea index (AHI) $\geq$10 events·h^{-1}); 2) significant disabling symptoms attributable to OSAS (especially excessive daytime sleepiness (Epworth Sleepiness Scale >10); and 3) willingness to try

CPAP with no obligation to continue the treatment if the benefits did not outweigh the disadvantages.

Patients with cancer or other severe associated diseases, especially other sleep disorders, thyroid disease, or a history of psychiatric illness, the possibility of inadequate follow-up because of either distance or unreliability, or refusal to participate were excluded from the study.

No patient was excluded *a priori* from the study because of nonwillingness to use CPAP treatment. Of the 44 patients initially enrolled, one patient did not tolerate CPAP therapy, two patients were lost to follow-up (removal), and two patients were excluded from re-evaluation because they themselves refused to complete the study due to emotional irritation (death of a close family member in one, and coronary artery bypass grafting in the other patient). Thus, analysis is based on the results of the remaining 39 patients. The 33 males and 6 females had a mean±SD age of 56±11 yrs, a mean body mass index of 31.3±5.4 $kg \cdot m^{-2}$, and a mean AHI of 46.8±21.8 $events \cdot h^{-1}$ of sleep.

Nineteen patients had a known or newly diagnosed arterial hypertension, six diabetes mellitus, four coronary artery disease, and one mild chronic obstructive pulmonary disease. Fourteen patients were treated with angiotensin converting enzyme inhibitors, 10 with diuretics, six with calcium channel blockers, and three with nitrates. Four of the patients with diabetes mellitus were treated with sulphonylureas or insulin.

All patients gave their informed consent to participate in the study. No control group was included into the study because sham CPAP therapy could have worsened both sleep and gas exchange, and it was believed to be unethical to withhold a well-established therapy from symptomatic patients for such a long time.

Polysomnography

All patients underwent overnight polysomnography (PSG; Somnostar 4100; SensorMedics Co., Yorba Linda, CA, USA) according to widely accepted methods [20]. It consisted of continuous polygraphic recording from surface leads for electroencephalography, bitemporal electro-oculography, submental and leg electromyography, and electrocardiography, and from noninvasive sensors for nasal and oral airflow, tracheal sounds (microphone), thoracic and abdominal respiratory effort (inductance plethysmography), and oxyhaemoglobin level (SatTrak™, finger-pulse oximeter; SensorMedics Co.). The transducers and lead wires permitted normal positional changes during sleep. Bedtime and awakening time were at each subject's discretion. PSG was terminated after final waking. The entire recording was supervised by a technician.

PSG records were scored in 30-s periods for sleep, breathing, and oxygenation. According to the commonly used clinical criterion, a breathing event during objectively measured sleep was defined as abnormal if either a complete cessation of airflow lasting ≥10 s took place (apnoea) or a reduction in respiratory airflow of ≥50% of the tidal volume lasting >10 s associated with an arousal or an oxygen desaturation of ≥4% could be discerned (hypopnoea). Obstructive apnoea was defined as absence of a tidal volume in the presence of paradoxical chest-wall motion. The average number of episodes of apnoea and hypopnoea per hour of sleep (AHI) was calculated. Sleep was staged manually using the methods of RECHTSCHAFFEN and KALES [21].

Subjects underwent one or two nights of CPAP titration with PSG to establish the therapeutic CPAP pressure at which breathing irregularities and arousals from sleep were lowest. They were instructed to use their CPAP devices every night and all night long. None of the patients received auto-CPAP or humidification.

Quality of life measures

Complaint list. The Complaint List evaluates the extent of subjective impairment due to physical and general complaints. It covers a particularly broad range of physical and mental disorders. The test is suitable for evaluating clinical course. The list comprises 24 items and the symptoms are scored on a four-point scale with the two extreme values "not at all" and "severely". Normal sample results show a mean of 14.26 and a standard deviation of 10.75 [22].

The Nottingham Health Profile Part I. The Nottingham Health Profile (NHP) measures patients' perception of their own health in terms of quality of life [23]. The NHP has been widely used, and a number of different national versions have been produced. The questions were translated into and validated in German [24]. Part 1 measures the subjective health status by asking for responses (yes or no) to a test of 38 simple statements relating to six dimensions of social functioning: emotional reactions; energy; pain; physical mobility; sleep; and social isolation. All statements are related to limitations of activity or aspects of distress. The answers are weighted with specific values, which enable a score from 0–100 for each dimension. A high score indicates a high degree of limitation. The scores are usually presented as a profile and not added to an overall score.

The Verbal Analogue-Scale "Quality of Life". The Verbal Analogue-Scale is a simple instrument to assess current global quality of life [11]. The patient is asked to score their current global quality of life as a number between 0 (completely dissatisfied) and 100 (completely satisfied). Despite its simplicity and ambiguous definition of quality of life, the Verbal Analogue-Scale provides a useful global assessment of current quality of life and can reveal finer quantitative differences than descriptive terms [25, 26]. Norm sample results show means ranging 75.5–77.6 (standard deviation 15.1–18.2).

Follow-up

Patients filled out the questionnaires of these three well-established measures of quality of life after baseline PSG and prior to initiation of CPAP therapy. During follow-up, the patients were additionally seen by their home physicians after 3 and 6 months.

After 9 months the 39 patients were asked to fill out the questionnaires again. In the following night they were re-evaluated by PSG (with CPAP). Compliance with prescribed CPAP therapy was based on the actual hours of CPAP appliance as registered by an integrated hour meter that could measure mask-on time.

Statistical analyses

Results are given as mean±SD. All p-values reported are two-tailed. Statistical analyses were performed with the computer software SPSS for Windows (SPSS Inc., Chicago, IL, USA). Intergroup differences were analysed with nonparametric tests (Wilcoxon, Mann-Whitney), independent associations with univariate and stepwise multiple linear regression analysis. The p-value was corrected for multiple comparisons using the Bonferroni adjustment. A p-value <0.05 was considered statistically significant.

Results

CPAP had a significant effect on respiratory parameters: AHI and the time during sleep with an oxygen saturation <90% decreased, and mean and minimum oxygen saturation during sleep increased significantly (table 1). PSG could document a significantly increase of deep sleep stages 3 and 4 (8.4±9.3% *versus* 15.0±9.7%, p<0.01), while light sleep stages 1 and 2 decreased slightly during follow-up (table 1).

The quality of life at baseline of the five dropouts was not significantly different from that of the whole group, as measured by all the three questionnaires.

The Complaint List as a whole indicated at baseline value above normal that normalized under CPAP treatment, the change was statistically significant (table 2). None of the 24 items of the Complaint List worsened during follow-up, but significant improvements could be documented for the items "A feeling of weakness" (p=0.037), "Fatigue" (p=0.002), "Excessive need of sleep" (p=0.0002), and "Pains in the shoulder and neck" (p=0.03).

The NHP Part 1 explored six dimensions of perceived health. The lowest score at baseline (9.7±20.5) was observed for the dimension of social isolation. The worst perceived dimension was energy with a score of 50.8±36.6. CPAP improved two dimensions of social functioning from the NHP Part 1: energy limitation decreased from 50.8±36.6 at baseline to 32.1±36.7 (p=0.01) during follow-up, and emotional reactions improved from 19.8±21.7 to 11.1±14.0 (p<0.05). The categories pain, physical mobility, and sleep showed slight improvement, while social isolation increased slightly, however within normal range.

Table 1. – Effect of continuous positive airway pressure treatment on body mass index, respiration, and sleep structure

	Baseline	Follow-up	Statistical significance
Body mass index, $kg \cdot m^{-2}$	31.3±5.4	30.8±4.8	NS
Apnoea/hypopnoea index, $events \cdot h^{-1}$	46.8±21.8	3.3±6.3	p<0.001
Sa,O_2min %	77.1±9.3	89.9±3.4	p<0.001
Sa,O_2mean %	92.3±3.1	94.7±1.8	p<0.001
t <90% %	21.3±24.5	2.3±3.6	p<0.001
Total sleep time min	390.6±53.3	384.7±48.5	NS
Stage wake %	8.0±8.9	7.6±8.0	NS
Sleep stage 1 + 2 %	71.6±14.4	64.2±11.6	NS
Sleep stage 3 + 4 %	8.4±9.3	15.0±9.7	p<0.01
Sleep stage REM %	12.1±9.7	15.0±10.9	NS

Values are given as mean±SD. Sa,O_2min: minimum oxygen saturation during sleep; Sa,O_2mean: mean oxygen saturation during sleep; *t* <90%: time during sleep with an oxygen saturation <90%; REM: rapid eye movement; NS: nonsignificant.

Table 2. – Effect of continuous positive airway pressure treatment on quality of life measures

	Baseline	Follow-up	p-value
Compliant list	26.4±9.9	20.4±11.1	0.005
Nottingham Health Profile			
Emotional reactions	19.8±21.7	11.1±14.0	0.05
Energy	50.8±36.6	32.1±36.7	0.01
Pain	21.8±27.5	19.6±25.2	NS
Physical mobility	21.1±16.0	17.9±19.3	NS
Sleep	28.5±27.7	20.1±24.9	NS
Social isolation	9.7±20.5	12.9±19.4	NS
Verbal Analogue-Scale	74.4±18.3	76.9±18.8	NS

Data are mean±SD.

Quality of life improved slightly, not significantly, as assessed by Verbal Analogue-Scale. With the exception of a weak correlation between mean oxygen saturation during sleep and the values of the Complaint List at baseline there was no significant correlation between nocturnal variables indicative of the severity of OSAS and daytime measures of quality of life (table 3).

All patients, with the exception of one, used their CPAP devices regularly during follow-up. CPAP units were run for a mean of 5.9±1.1 (range, 2.9–7.9) $h \cdot night^{-1}$. Mean CPAP pressure during follow-up was 6.4±1.6 mbar. All patients ascertained that their CPAP use in the days prior to re-evaluation was typical of that during the complete follow-up. There was no significant correlation between CPAP compliance and change in the quality of life measures (Complaint List: r= -0.06, p=0.77; NHP: 1) emotional reactions: r= -0.09, p=0.63; 2) energy: r= -0.03, p=0.87; 3) pain: r= -0.22, p=0.22; 4) physical mobility: r=0.02, p=0.91; 5) sleep: r= -0.19, p=0.30; 6) social isolation: r= -0.12, p=0.52; Quality of life (Verbal Analogue-Scale): r= -0.06, p=0.79).

Discussion

The main result of the study is that long-term CPAP therapy is effective in improving not only pathological breathing patterns but also parameters that indicate quality of life in patients with OSAS.

Table 3. – Correlations between nocturnal variables indicative of the severity of obstructive sleep apnoea syndrome and daytime measures of quality of life

	Apnoea/hypopnoea index		Sa,O_2mean	
	r	p-value	r	p-value
Complaint list	0.12	0.51	0.41	0.04
Nottingham Health Profile				
Emotional reactions	-0.15	0.39	0.30	0.11
Energy	-0.02	0.92	0.20	0.31
Pain	-0.05	0.76	0.19	0.33
Physical mobility	-0.16	0.38	-0.02	0.91
Sleep	0.15	0.39	0.00	1.00
Social isolation	-0.07	0.70	0.17	0.39
Verbal Analogue-Scale	0.23	0.23	-0.10	0.66

Data are mean±SD. Sa,O_2mean: arterial oxygen saturation.

Previous research on quality of life measures demonstrated that short-term treatment with CPAP for 4 or 5 weeks, respectively, can improve cognitive performance [12], symptoms of OSAS and daytime function [13, 19], and quality of life [14, 15, 18]. A recently published study demonstrated that the relief of sleepiness and other OSAS-related clinical symptoms and improvement in perceived health status was much greater in patients receiving conservative and CPAP treatment compared with those only receiving conservative treatment, even after 3 months of treatment [17]. Another study in 80 consecutive patients showed that CPAP use over 6 months was greater among patients receiving intensive than among those receiving standard support, with greater improvements in OSAS symptoms, mood, and reaction time in the intensively supported group [27]. Furthermore, a retrospective French study demonstrated that patients who continued CPAP treatment for >6 months had a relatively good perception of their health. The perceived health as evaluated by the NHP Part 1 was good (mean score <50) for at least 75% of the patients in each dimension explored [16].

This study proves a beneficial effect of CPAP over 9 months in a prospective design, even though not all three quality of life measures showed significant improvements.

The Complaint List showed a subjective impairment due to physical and general complaints at baseline, which improved significantly under treatment. This was to be expected since it is known that OSAS results in hypersomnolence and reduced daytime performance.

As in the French study [16] all dimensions explored with the help of the NHP Part 1 had a mean score of <50 under treatment. Compared with the baseline value, the dimensions "emotional reactions" and "energy" improved significantly, which can well be explained by the fact that it is specifically these fields that are heavily affected by OSAS. Correspondingly, it is not surprising that the categories "pain", "physical mobility", and "social isolation" are neither elevated at baseline, nor do they improve significantly under CPAP treatment. The same applies to the dimension "sleep", which may be unexpected at first sight; however, OSAS patients only rarely complain of an impairment of sleep but rather of an impaired daytime performance, not realizing that this is caused by a sleep disturbance. On the other hand, the category "sleep" did show a slight improvement under CPAP treatment, and it can be speculated that the lack of statistical significance is due to the small sample size.

Although the patients′ "energy" improved significantly under CPAP treatment, this dimension of the NHP remained the one most negatively perceived. This is in accordance with the findings of two other studies [16, 28] and may indicate the inability of CPAP to reverse all of the pathological symptoms of OSAS, or, alternatively, be directly related to CPAP therapy. Another explanation is the limitation of the measure and the fact that patients′ sleep habits may also effect their energy level independent of CPAP treatment.

According to the Verbal Analogue-Scale, quality of life was not reduced at baseline, although it improved slightly under CPAP treatment, this change was not statistically significant. There are several reasons that could account for the obvious failure of this measure to mirror the problems patients with OSAS have to cope with. Firstly, the questions asked in the Verbal Analogue-Scale do not specifically address aspects of life thought to be affected by OSAS. Moreover, some studies have demonstrated that the clinical status of the patient does not always agree with their personal health perception [28, 29] and therefore, the results of the current study might suggest a high prevalence of symptom minimization [30].

Interestingly, with the exception of a weak correlation between mean oxygen saturation during sleep and the values of the Complaint List at baseline, a significant correlation between the severity of OSAS and the general health status as assessed by the three quality of life measures could not be demonstrated. This shows that the severity of OSAS as evaluated by conventional nocturnal measures and the extent of daytime impairment are not necessarily related, as demonstrated recently in patients with OSAS [28, 31], and underlines the necessity to observe not only the physiological disturbances of OSAS but also the impact on the patients′ quality of life.

An explanation for the relatively normal pretherapy scores and their relatively subtle improvements under treatment may be that the specific symptoms and limitations induced by OSAS are not evaluated sensitively enough in these measures. To counterbalance this shortcoming, three different quality of life measures were employed in parallel, which address different aspects of quality of life.

A limitation of the study is the lack of a control group, but it was believed that CPAP could not be withheld from symptomatic patients for 9 months. Therefore, it cannot be ruled out that the beneficial CPAP effects were overrated. Nevertheless, there are data from short-term studies which allow the estimation of the placebo effect. To the authors′ knowledge, there are four studies on the quality of life including a placebo group. ENGLEMAN *et al.* [12] showed that during a 4-week course of CPAP therapy subjective well-being improved in the CPAP group by about twice the effect in the placebo group. In a smaller group of patients, a similar benefit of CPAP over placebo was reported by the same group [13]. In a further study, this group showed that CPAP therapy also significantly improved well-being in patients with mild sleep apnoea/hypopnoea syndrome as assessed by the Epworth sleepiness scale, a symptom score, performances on two of seven cognitive tasks, depression score, and five subscales of the Short Form-36 health/functional status questionnaire [19].

JENKINSON *et al.* [18] chose another approach, using patients under subtherapeutic CPAP therapy as a control group. In this study patients were followed for 4 weeks. The results remarkably resembled those in the studies by ENGLEMAN *et al.* [12, 13, 19], showing that the measures of subjective well-being improved about two-fold compared with placebo. Therefore, from the short-term studies available it can be deduced that placebo or subtherapeutic CPAP have measurable positive effects on subjective well-being, but that there is a clear quantitative difference between CPAP and placebo effects.

In conclusion, the beneficial effects of CPAP on the quality of life are not just short-term, but can be demonstrated after a period of 9 months. This may be an additional argument in favour of a decision for the initiation of CPAP treatment of OSAS, even in spite of decreasing financial resources for medicine.

Since patients who can feel a significant improvement in their quality of life are likely to show a high level of compliance with continuous positive airway pressure treatment, further controlled studies of obstructive sleep apnoea syndrome patients are required to help identify promising compliers even at baseline.

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