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Reduced Hospitalization with Cardiovascular and Pulmonary Disease in Obstructive Sleep Apnea Patients on Nasal CPAP Treatment

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Summary: Cardiovascular and pulmonary disease (CVPD) is common in patients with obstructive sleep apnea syndrome (OSAS). This retrospective study addressed the accumulated in-hospital time during 2 years prior to treatment with nasal continuous positive airway pressure (nCPAP) as compared to 2 years after initiating of nCPAP in patients with OSAS and CVPD. A cohort representing all patients (n = 88) receiving nCPAP during the period 1988–1994 at the Skövde Central Hospital, Skövde, Sweden, was studied. Data collection was based on interviews with patients as well as reviews of clinic charts. All hospitalizations and diagnostic codes by any type were thereby successfully gathered for the whole group. Six patients with confounding serious diseases were excluded from the analysis. A CVPD diagnosis (ICD-9, codes 401–435 and 490–496) was found in 54 out of 82 patients (66%), of whom 36 of 58 were nCPAP users (62%) and 18 of 24 were nonusers (75%). In 54 sleep apneics with CVPD, 31 were hospitalized acutely under one or more of these diagnostic codes during the study period of 4 years. The total number of in-hospital days due to CVPD in the nCPAP users (n = 19) before nCPAP prescription was 413 days (median 10, range 3–66) compared to 54 days (median 0, range 0–25) after nCPAP ($p < 0.0001$). The corresponding values for the nonuser group (n = 12) was 137 days (median 8.5, range 0–42) before and 188 days (median 9.5, range 0–47) after the nCPAP prescription (ns). We conclude that nCPAP treatment reduces the need for acute hospital admission due to CVPD in patients with OSAS. This reduction of concomitant health care consumption should be taken into consideration when assessing the cost–benefit evaluation of nCPAP therapy. **Key Words:** Sleep apnea—Cardiovascular—Morbidity—nCPAP—Cost–utility.

Obstructive sleep apnea syndrome (OSAS) is estimated to affect 2–4% of the general population (1,2). Complications are numerous and nonspecific, including neuropsychiatric disturbance, daytime sleepiness, decreased concentration, memory loss, irritability, depression, decreased libido, and nocturnal enuresis (3,4). Moreover, systemic and pulmonary hypertension (5–7) as well as right heart failure, cardiac arrhythmias (8–10), and increased risk of myocardial infarction (11) have been associated with OSAS. In addition, increased incidence and poor functional outcome of stroke demonstrated in obstructive sleep apnea (OSA) (12,13) and cerebral blood flow may be reduced during apneas (14). Obstructive sleep apnea syndrome may also play an important role for symptom severity in nocturnal asthma (15). In a recent study, an associated obstructive airway disease was found in approximately 10% of OSAS patients, and the risk of developing respiratory failure and cor pulmonale was increased in this group compared to other OSAS patients (16).

Nasal continuous positive airway pressure (nCPAP) is recognized as a major treatment modality in OSAS (3). Numerous studies have shown the effectiveness of nCPAP in eliminating apneas and symptoms of sleep-disordered breathing (17). In addition, crude mortality in OSAS may be reduced by nCPAP treatment (18,19).

Long-term compliance with nCPAP is reported to range between 63 and 90% (20–22). Numbers vary depending on the definition of compliance used, experience in initiating therapy, the adequacy of follow-up, and, probably, the type of nCPAP device and mask used. Cost of the nCPAP system may be an important limiting factor for therapy initiation when the economical resources are restricted. Still, well-tolerated nCPAP therapy in

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TABLE 1. *Patient characteristics at baseline, ODI, and nadir saturation (SaO_2min) as well as prescribed nCPAP level at the last follow-up investigation in each subgroup of patients in both nCPAP-user and nonuser groups*[a]

	nCPAP users			Nonusers		
	All users	Without CVPD	With CVPD	All nonusers	Without CVPD	With CVPD
Number (n)	58	22	36	24	6	18
Age (years ± SD)	54.2 ± 11.4	50.2 ± 10.9[c]	56.7 ± 11.2[c]	56.1 ± 7.8	56.1 ± 6.6	56.1 ± 8.4
Sex (male/female)	47/11	19/3	28/8	20/4	5/1	15/3
BMI (kg/m^2 ± SD)	32.6 ± 5.8[b]	30.7 ± 4.7	33.7 ± 6.2	36.1 ± 9.3[b]	32.9 ± 4.2	37.1 ± 10.3
ODI pretreatment (events/hour ± SD)	36.1 ± 18.3	34.2 ± 17.6	36.9 ± 19.4	37.1 ± 15.2	34.5 ± 15.3	38.1 ± 15.6
ODI on treatment (events/hour ± SD)	3.0 ± 2.8	2.1 ± 1.7	3.5 ± 3.3	—	—	—
SaO_2min pretreatment (% ± SD)	70.1 ± 14.3	70.9 ± 16.0	69.3 ± 13.8	69.9 ± 11.9	76.7 ± 3.7	67.0 ± 14.7
SaO_2min on treatment (% ± SD)	89.5 ± 4.0	90.7 ± 3.4	88.8 ± 4.2	—	—	—
Prescribed nCPAP level (cm H_2O ± SD)	7.8 ± 1.6	7.6 ± 1.1	7.8 ± 1.9	7.8 ± 2.0	6.3 ± 1.4	8.4 ± 1.9

ODI, oxygen desaturation index; nCPAP, nasal continuous positive airway pressure; CVPD, cardiovascular and pulmonary disease; BMI, body mass index; SD, standard deviation.

[a] Statistics by unpaired Student's *t* test.

[b] Comparing BMI in all nCPAP users and nonusers ($p = 0.044$).

[c] Comparing age in patients with CVPD and without CVPD in the user group ($p = 0.035$).

moderate or severe OSAS seems to have a very favorable cost–utility ratio (23).

The present study aimed to quantify acute hospitalization due to cardiovascular and pulmonary symptoms before and after nCPAP treatment of OSAS patients. A reduced need for acute hospitalization would support a direct or indirect causative relationship between OSAS and cardiovascular and pulmonary disease (CVPD), thereby introducing additional factors in the evaluation of cost effectiveness of long-term nCPAP treatment in OSAS.

MATERIALS AND METHODS

Study population

This retrospective study was undertaken in all (n = 88) patients with OSAS-prescribed nCPAP at the Respiratory Division, Department of Medicine, Skövde Central Hospital, Skövde, Sweden during 1988–1994. Data collection was based on interviews with patients as well as reviews of the clinic charts. All hospitalizations and diagnostic codes by any type were successfully gathered for the whole group. Six patients with confounding serious diseases (two cases of uremia, one each with rheumatoid arthritis, biliary cirrhosis, multiple system atrophy, and brain tumor) were excluded from the analysis as it was impossible to determine the need of hospitalization for the symptoms per se in detail. The study population (n = 82) was analyzed in two groups, depending on acceptance of nCPAP therapy and, subsequently, in subgroups of nCPAP users and nonusers (for definition see below) depending on documented concomitant cardiovascular or pulmonary diagnosis (CVPD) and/or documented hospitalization for any time during the 4-year study period (Tables 1 and 2).

Basal diagnostic procedures

All patients had previously undergone standard investigation for the diagnosis of OSAS in in the sleep laboratory, Department of Otorhinolaryngology, Skövde Central Hospital. Diagnostic criteria included significant sleep-disordered breathing (see below) and a documented complaint of excessive daytime sleepiness. The sleep study included nocturnal recording of respiratory and body movements and ballistocardiogram (BCG) via a static charge-sensitive bed (SCSB; Bio-matt, Biorec OY, Turku, Finland) and, additionally, monitoring of arterial oxygen saturation (SaO_2) via a finger probe (BIOX 3740, Ohmeda, Boulder, CO) under 6 hours after sleep onset. All signals were continuously sampled, displayed on-line, and stored in a computer (BR11 software). Increasing amplitude of respiratory movements, simultaneous increase in respiratory variations of BCG, and subsequent body movements (arousal movements) were recorded as obstructive events as earlier defined by Alihanka (24). A decrease in oxygen saturation of 4% or more was defined as a significant desaturation. The number of significant desaturations per hour of supervised estimated sleep (oxygen desaturation index, ODI) and the minimum oxygen saturation (SaO_2min) were determined. Respiratory disturbance index (RDI) was defined as the average number of obstructive events with significant desaturation per hour of estimated sleep. RDI was scored manually.

Nasal CPAP therapy

All patients in this study had been admitted to the Respiratory Division, Department of Medicine, for initiation of nCPAP treatment based on a RDI exceeding 10/hour and daytime symptoms including excessive sleepiness. Nasal CPAP was titrated according to a stan-

TABLE 2. *Particulars of overnight sleep study and compliance with nCPAP treatment in patients with concomitant CVPD and acute hospitalization*

Patient no./sex	Age (years)	BMI (kg/m²)		ODI (n/hour)		SaO_2min (%)		nCPAP level (cm H_2O)	Estimated nCPAP use		Documented (objectively) (see text)
		Pretreatment	On treatment	Pretreatment	On treatment	Pretreatment	On treatment		Hours/hours of sleep/week	%	
nCPAP users											
1/F	46	35.1	34.9	12	0	82	92	5.0	49/56	88	Yes
2/M	51	31.3	30.7	28	3	84	86	7.0	35/49	71	Yes
3/F	51	30.4	31.9	50	2	80	90	7.5	49/56	88	No
4/M	52	33.1	30.3	14	2	80	92	7.5	49/49	100	Yes
5/M	61	51.7	50.0	40	4	75	86	8.0	56/56	100	No
6/M	62	29.7	28.1	25	5	75	89	8.0	49/56	88	Yes
7/M	63	31.8	30.9	22	4	84	88	7.0	49/56	88	Yes
8/M	63	24.1	25.1	15	0	82	92	5.0	42/42	100	No
9/F	64	36.9	34.8	30	8	79	88	5.0	35/35	100	Yes
10/M	65	31.0	30.4	50	4	40	79	7.0	49/49	100	No
11/M	66	27.8	27.8	20	0	84	94	7.0	56/56	100	Yes
12/M	67	37.5	34.7	60	3	66	89	6.5	56/56	100	No
13/M	68	37.9	36.8	50	10	68	86	9.0	42/49	86	Yes
14/M	68	42.3	42.3	60	15	65	82	9.0	42/49	86	Yes
15/M	69	42.3	38.2	80	5	32	75	13.0	16/35	46	Yes
16/F	73	28.8	28.3	25	5	80	93	7.0	25/49	51	Yes
17/F	73	27.0	29.2	18	8	79	85	7.5	49/49	100	Yes
18/M	74	24.2	24.5	30	3	77	91	9.0	42/49	86	Yes
19/M	79	28.7	29.2	50	8	70	90	7.0	35/49	71	No
Mean (SD)	63.9 (8.8)	33.2 (6.9)	32.5 (6.2)	35.7 (19.1)	4.7 (3.8)	72.7 (14.3)	87.7 (4.9)	7.5 (1.8)		84.5 (19.3)	
Nonusers											
1/M	49	46.9	31.1[a]	60	3[a]	54	88[a]	9.0	0/0	0	Yes
2/M	51	42.7	39.9	30	—[b]	55	—	13.0	0/0	0	Yes
3/M	53	40.1	37.1	32	—	80	—	5.0	0/0	0	Yes
4/M	55	53.7	33.7[a]	15	4[a]	75	92[a]	7.5	0/0	0	Yes
5/F	57	62.2	51.9	32	—	64	—	10.0	0/0	0	Yes
6/M	58	28.4	27.0	12	—	84	—	7.0	0/0	0	Yes
7/M	61	32.0	32.0	50	—	66	—	8.0	14/56	25	Yes
8/M	73	25.8	25.2	20	—	90	—	11.0	0/0	0	Yes
9/M	50	34.9	36.7	20	—	74	—	7.0	14/56	25	Yes
10/M	56	38.3	37.1	65	—	64	—	7.5	15/56	27	Yes
11/F	68	28.0	27.0	42	—	60	—	10.0	0/0	0	Yes
12/M	73	34.5	33.0	52	—	37	—	9.0	0/0	0	Yes
Mean (SD)	58.7 (8.5)	39.0 (10.0)	34.3 (7.2)[c]	35.8 (17.8)		67.0 (14.7)		8.7 (2.1)		6.4 (11.6)	

CVPD, cardiovascular and pulmonary disease; BMI, body mass index; ODI, oxygen desaturation index, SaO_2min; SD, standard deviation.
[a] After gastroplastic surgery.
[b] Not documented.
[c] Comparing BMI before and after nCPAP prescription in nonusers ($p = 0.041$, using paired t test).

dardized routine procedure. The aim of this sleep study was not diagnostic but to manage nCPAP treatment, and ODI was taken into consideration in adjusting nCPAP levels. In brief, treatment was initiated at a pressure of 5 cm H_2O and progressively increased by 1-cm H_2O increments until oxygen desaturations were eliminated. Prescribed pressures ranged between 5 and 13 cm H_2O. On the following day, information was given to each patient regarding mechanism of action and technical function of the nCPAP device. Two different types of commercially available nCPAP devices were used: REM-star (n = 75) and Sleep Easy III (n = 7) (Respironics, Monroeville, PA). Patients were instructed to use the device throughout the night every night of the week. A follow-up investigation with the patient's nCPAP device was undertaken within 6 months of treatment initiation to ensure effectiveness of equipment and effective pressure. This investigation, which was repeated yearly, included a classification of ODI and SaO_2min. Patient characteristics at baseline, ODI, SaO_2min, and prescribed nCPAP level at the last follow-up investigation in each subgroup of patients in both user and nonuser groups are shown in Tables 1 and 2.

Observation period

At the time of investigation, all individuals had been on nCPAP treatment for at least 2 years. A time span

covering 2 years prior to and 2 years following nCPAP prescription was therefore defined as the observation period.

Nasal CPAP users and nonusers

Regular nCPAP use, with a self-reported minimum use of 4 hours per night for at least 4 days per week (complete data not shown), was found in 58/82 patients (71%). The nCPAP use was not quantified objectively in the whole study population because of the lack of available methods by the time the first nCPAP devices were prescribed. However, we were able to objectively quantify nCPAP use by timecounter of the devices in patients receiving nCPAP during the last 2 years of the inclusion period (Table 2). Nasal CPAP treatment was not tolerated in 24 out of 82 patients (29%), 15 of these returning the device within the first month after prescription. Nine patients used nCPAP less than a few hours per week and were classified as noncompliant.

Classification and evaluation of CVPD

Data collection was based on reviews of all clinic charts and confirmed by direct patient interviews. The definition of CVPD was based on ICD (*International Classification of Diseases*)-9 codes (25) 401–435 and 490–496, inclusive. The frequency of hospitalization episodes and total in-hospital time based on these disease codes during 2 years before and 2 years after initiating nCPAP was registered for each patient. All hospitalization episodes before and following nCPAP therapy had taken place at the Skövde Central Hospital, Skövde, Sweden (study hospital), or at three regional hospitals within a 100-km radius of the study hospital. Due to the structure of the Swedish health care system, we were also able to ascertain that no hospitalization had taken place outside the local hospital. All such hospitalization, when occurring, is automatically reported to the local hospital by means of the nationwide interhospital charging system. In-hospital time for procedures associated with the diagnosis of OSAS or for evaluation of the nCPAP treatment was excluded from calculation. A CVPD diagnosis was found in 54 out of 82 (66%) patients (Table 1). Acute hospitalization at any time during the observation period of 4 years was required in 31 (57%) of the patients with a CVPD diagnosis. The number of in-hospital days due to acute worsening of the CVPD before and after nCPAP initiation was investigated in these 31 patients. Additionally, the cost–utility of the nCPAP treatment was analyzed by comparing the standardized defined minimal hospital care costs in a medical ward due to CVPD before and after nCPAP prescription.

TABLE 3. *Individual numbers of pharmacological agents (ATC codes C01–C08 and R03) prescribed to patients with concomitant CVPD with acute hospitalization*

		Separate pharmacological agents (n)[a,b]	
	Patient no.	Before nCPAP	On nCPAP
nCPAP users	1	2	2
	2	3	3
	3	6	5
	4	5	5
	5	4	5
	6	1	1 (pacemaker)
	7	2	1
	8	3	2
	9	5	5
	10	3	1 (coronary by-pass surgery)
	11	1	1
	12	3	3
	13	7	7
	14	1	1
	15	6	5
	16	6	6
	17	2	2
	18	6	6
	19	2	2
Mean ± SD		3.6 ± 2.0	3.3 ± 2.1 (ns)
Nonusers	1	2	2 (gastroplastic surgery)
	2	3	3
	3	2	3
	4	2	2 (gastroplastic surgery)
	5	2	3
	6	2	2 (PTCA)
	7	2	5 (died)[c]
	8	2	4 (pacemaker)
	9	1	2
	10	0	3
	11	0	2
	12	0	2
Mean ± SD		1.5 ± 1.0	2.8 ± 1.0 (p = 0.0029)

ATC, anatomical therapeutic chemical classification; CVPD, cardiovascular and pulmonary disease; nCPAP, nasal continuous positive airway pressure; SD, standard deviation.

[a] Two patients in the user group and four in the nonuser group received nonpharmacological treatment during the observation period (see text).

[b] Statistics by paired *t* test.

[c] See text.

Pharmacological treatment

The number of registered pharmacological agents prescribed for treatment of concomitant CVPD (ICD-9, codes 401–435 and 490–496) before and on nCPAPtreatment was determined for each patient requiring acute hospitalization (see Table 3). Drugs that were registered include those listed within the ATC (anatomical therapeutic chemical classification system) codes C01–C08 and R03 (26).

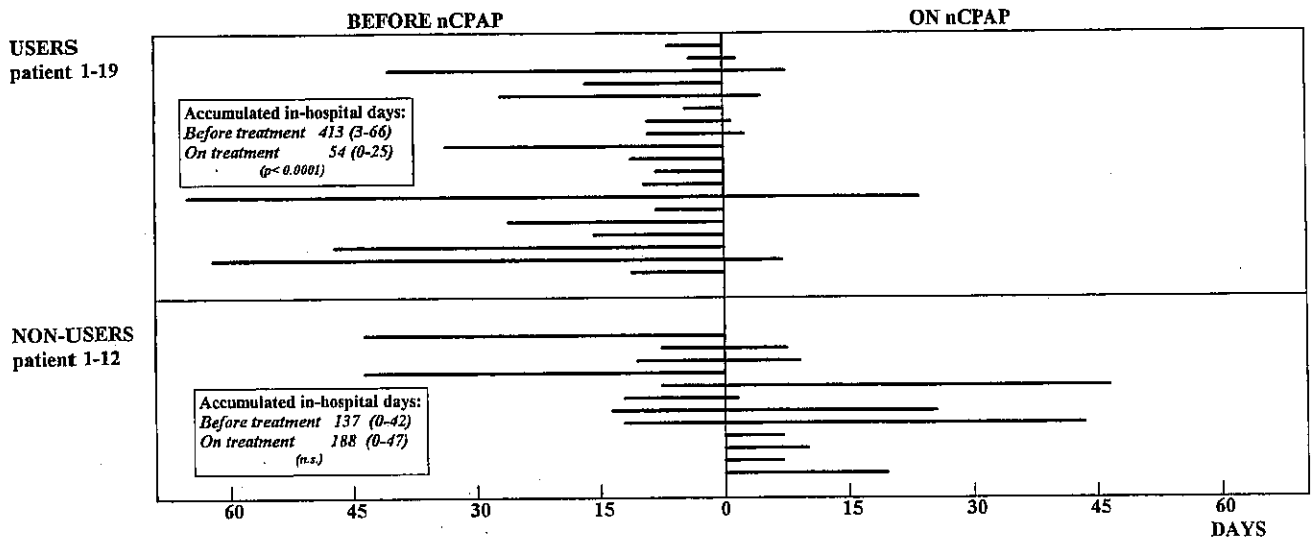

FIG. 1. The total number of in-hospital days for patients with obstructive sleep apnea syndrome (OSAS) and cardiovascular or pulmonary diseases (CVPD) during 2 years prior to treatment with nCPAP as compared to 2 years after nCPAP prescription. Shown are data from nCPAP users and patients noncompliant with treatment (nonusers) with acute hospitalization due to CVPD. Statistics by Wilcoxon's signed-ranks test.

Statistics

Data represents means ± standard deviation (SD) if not otherwise stated. Nasal CPAP users and nonusers, as well as subgroups concerning the presence of a CVPD diagnosis, were compared by unpaired Student's *t* test for variables measured on a continuous scale and chi-square tests for categorical variables. Statistical comparison between number of pharmacological agents as well as body mass index (BMI) before and after nCPAP prescription in the hospitalized patients (users and nonusers) was made using paired *t* test, respectively. The total number of in-hospital days as well as the total number of hospital admissions due to CVPD were expressed as median values due to the skewed distribution. Statistical comparison between median values concerning hospitalization before and on nCPAP both in users and nonusers was performed using Wilcoxon's signed-ranks test. A p value of 0.05 or less was regarded as statistically significant.

RESULTS

Basic characteristics of study material

Regular nCPAP use was obtained in 58 of 82 patients (71%). Age, sex, severity of sleep apnea at entry, and prescribed nCPAP level were similar in users and nonusers. Body mass index was higher in the nonuser group ($p = 0.044$) (Table 1). No serious side effects were seen after nCPAP treatment. Reasons for treatment interruption were similar to those previously described, i.e. runny nose, other nonspecific nasal side effects, claustrophobia, and discomfort from noise.

A concomitant CVPD diagnosis was found in 66% ($n = 54$) of the total study cohort (Table 1), and there was a slight overrepresentation in the nonuser group (75%, $n = 18$) compared to the nCPAP users (62%, $n = 36$).

In the nCPAP user group, patients with CVPD were older than those without CVPD ($p = 0.035$). In the nonuser group, patients with CVPD were more obese than those without CVPD, but this was not statistically significant because of the small number of patients in the subgroups. Other characteristics did not differ between the subgroup of patients with or without concomitant CVPD in neither the user nor the nonuser group (Table 1).

Hospital admissions due to CVPD

A record of hospital admission due to CVPD was found in 19/58 (33%) nCPAP users and 12/24 (50%) of nonusers during the study period. Patient characteristics including severity of sleep disordered breathing and particulars of nCPAP-use in this subgroup of patients with CVPD requiring acute hospitalization, are shown in Table 2. Complaince with treatment was high (mean 84.5 ± 19.3% of hours spent asleep) in the user group. Nonusers with CVPD were marginally heavier than users at the start of the study, while there was no difference between groups at the end of the study period (Table 2). Two patients in the nonuser group had undergone gastroplastic surgery.

The total number of in-hospital days due to CVPD

TABLE 4. *Reasons for acute hospitalization as well as in-hospital days and number of hospital admissions in patients with concomitant CVPD before and on nCPAP treatment*[a]

	Patient no.	Reasons for acute hospitalization (ICD-9 codes 401–435 and 490–496)	Calculated in-hospital days/year		Total number of hospital admissions	
			Before treatment	On treatment	Before treatment	On treatment
nCPAP users	1	Paroxysmal supraventricular tachycardia	4	0	4	0
	2	Angina pectoris	1.5	1	2	1
	3	Bronchial asthma	21	4.5	8	3
	4	Myocardial infarction, cardiac failure	8.5	0	3	0
	5	Angina pectoris, cardiac failure	14	3	4	1
	6	Sinus bradycardia with sinus pauses	2.5	0	5	0
	7	Paroxysmal atrial fibrillation	4.5	0.5	3	1
	8	TIA, angina pectoris	4.5	2	2	1
	9	Myocardial infarction, angina pectoris	17	0	4	0
	10	Myocardial infarction	5	0	2	0
	11	TIA	3.5	0	2	0
	12	Cardiac failure	4.5	0	1	0
	13	Chronic atrial fibrillation, cardiac failure	33	12.5	5	3
	14	Bronchial asthma	3.5	0	2	0
	15	Bronchial asthma, cardiac failure	13	0	2	0
	16	Chronic atrial fibrillation, cardiac failure, respiratory failure	7.5	0	3	0
	17	Acute exacerbation of COPD, respiratory failure	23.5	0	3	0
	18	Chronic atrial fibrillation, cardiac failure	30.5	3.5	5	1
	19	Angina pectoris	5	0	2	0
		Total number (median)	207 (5)	27 (0) ($p = 0.0001$)	58 (3)	11 (0) ($p = 0.0001$)
Nonusers	1	Respiratory failure, cardiac failure	21	0	2	0
	2	Angina pectoris, cardiac failure	4	4	1	2
	3	Paroxysmal atrial fibrillation	4.5	5	3	6
	4	Respiratory failure, cardiac failure	20	0	1	0
	5	Respiratory failure, cardiac failure	3.5	23.5	2	14
	6	Myocardial infarction, TIA	5	1	1	1
	7	Hypertension, myocardial infarction, respiratory failure	5.5	14	1	2
	8	Cardiac failure, third degree AV-block	5	22.5	2	5
	9	Myocardial infarction, angina pectoris	0	4.5	0	2
	10	Hypertension	0	6	0	1
	11	Myocardial infarction, angina pectoris	0	4.5	0	2
	12	Cardiac failure	0	9	0	4
		Total number (median)	69 (4)	94 (5) (ns)	13 (1)	39 (2) ($p < 0.05$)

CVPD, cardiovascular and pulmonary disease; nCPAP, nasal continuous positive airway pressure; ICD, *International Classification of Diseases*; TIA, transient ischemic attack; COPD, chronic obstructive pulmonary disease; AV-block, atrioventricular block.

[a] Statistics by Wilcoxon's signed-ranks test.

before nCPAP in the user group was 413 days (median 10, range 3–66) (Fig. 1). After nCPAP, there was a reduction ($p < 0.0001$) to 54 days (median 0, range 0–25). The corresponding values for the nonuser group were 137 days (median 8.5, range 0–42) before and 188 days (median 9.5, range 0–47) (ns) after the nCPAP prescription date. The total number of hospital admissions in the user group with CVPD decreased from 58 (median 3, range 1–8) to 11 (median 0, range 0–3) ($p = 0.0001$), while it increased from 13 (median 1, range 0–3) to 39 (median 2, range 0–14) ($p < 0.05$) in the nonusers (Table 4). After correction of the observation time to a yearly basis, there was a reduction of in-hospital days due to CVPD from 207 to 27 days ($p = 0.0001$) in the nCPAP users and an increase from 69 to 94 days (ns) in the nonusers (Table 4).

Concomitant pharmacological treatment in patients with acute hospitalization

The CVPD diagnosis (ICD-9 codes 401–435 and 490–496, Table 3) resulted in concomitant medication in all patients during the observation period. The total number of pharmacological agents prescribed due to CVPD increased in non-nCPAP users from 18 (mean 1.5 ± 1.0) to 33 (mean 2.8 ± 1.0) ($p = 0.0029$) during the second half of the observation period, while there was no significant change before (68, mean 3.6 ± 2.0) and after (63, mean 3.3 ± 2.1) nCPAP prescription in the user group. One patient in the noncompliant group, but none in the user group, died during the 2 years after initiating nCPAP treatment. Two patients in the user group had required nonpharmacological treatment (coronary by-pass surgery, pacemaker implantation)

for CVPD before nCPAP. Two patients in the nonuser group underwent percutaneus transluminal coronary angioplasty (PTCA) and pacemaker implantation, respectively, for CVPD during the follow-up period after nCPAP prescription (Table 3).

Health economical aspects

The minimal daily cost for hospital care at the Skövde Central Hospital, Skövde, Sweden, is approximately SKr 2,000 (~US$ 294). On a yearly basis, the in-hospital time for nCPAP users before prescription of nCPAP due to acute worsening of CVPD (207 days) represented a minimum cost of SKr 414,000 (~US$ 60,800). After initiation of nCPAP treatment, the time in-hospital (27 days) corresponded to a yearly minimum cost of SKr 54,000 (~US$ 7,900). In the nonuser group, however, there was an increase in the yearly cost for in-hospital time due to CVPD from Skr 138,000 (~US$ 20,300) to SKr 188,000 (~US$ 27,600).

DISCUSSION

The present study has demonstrated a high prevalence of concomitant CVPD in an unselected population of patients with moderate-to-severe OSAS and a considerable reduction of in-hospital days due to CVPD in these patients after initiation of nCPAP treatment. Effective compliance with nCPAP was on the order of 70%.

The patients had previously undergone standard investigation for the diagnosis of OSAS by a static charge-sensitive bed (SCSB) analysis including respiratory and body movements, ballistocardiogram, and additional monitoring of arterial oxygen saturation. This method, first described by Alihanka (24), has a high sensitivity (0.92–0.98) for detection of obstructive sleep apnea (27), although the specifity is lower (0.61–0.68). However, the false-positive findings were not considered as a severe methodological limitation as they were explained by frequent episodes of periodic hypopnea accompanied by arterial oxygen desaturation and arousal (27). When starting nCPAP treatment and adjusting nCPAP levels, only ODI was taken into consideration. It was therefore disregarded whether the apneas were purely obstructive or in part central by the time of the sleep study. Nevertheless, the present study was focused on the clinical outcome expressed as the need for acute hospitalization due to CVPD after initiation of nCPAP therapy in an unselected group of patients prescribed nCPAP.

The definition of compliance with nCPAP in this study was set to 4 hours at least 4 days per week in accordance with the effective threshold previously determined by Reeves-Hoche et al. (20). Using this threshold, subjective compliance was found to be in the order of 70%, which corresponds well with that demonstrated in studies objectively (20) or subjectively (21,22) assessing compliance. The subjective assessment of nCPAP use for the patients prescribed their devices in the earlier period between 1988 and 1994 may constitute a weakness of our study protocol but is explained by the lack of available and reliable methods to assess compliance by the time these devices were prescribed. No significant association between the frequency of nCPAP use and in-hospital time or frequency of hospitalization could be demonstrated. Although a direct dose dependency between time on nCPAP and improvement of health may have been expected at least in some types of CVPD assessed (e.g. cardiac failure) (28), any such association may have been masked by the low absolute number of patients studied.

Nasal CPAP is a major treatment modality in OSAS (3). Several studies suggest a considerable beneficial effect of nCPAP on OSAS-related cardiovascular and pulmonary morbidity such as hypertension (29–31), cardiac failure (28), nocturnal angina (32), bradyarrythmia (10), and nocturnal asthma (33) as well as acute exacerbation of chronic obstructive pulmonary disease (COPD) (34). In contrast, nCPAP-related reduction of crude mortality in sleep apneics remains to be convincingly documented, although it has been suggested by previous studies (18,19). The present study has demonstrated that not only the overall time spent in hospital due to CVPD was reduced on nCPAP treatment but also the number of admissions. These reductions were not explained by a modified attention to the general health status due to concomitant nCPAP treatment. In fact, no hospital admissions were initiated by personnel related to the actual treatment of the condition of sleep-disordered breathing. Neither were the reductions explained by modifications of pharmacological treatment of the CVPD. If anything, there tended to be a slight reduction in the number of drugs prescribed for conditions of CVPD, suggesting an actual reduction of symptom load of CVPD after nCPAP. Finally, the subgroup of patients with CVPD, but noncompliant with nCPAP treatment, exhibited a time-dependent increase in hospitalization days and number of admissions during the study period. This group did not differ from the compliant group in any obvious characteristics other than a higher BMI that may have confounded the outcome. Still, in this subgroup, one patient died and four patients underwent other therapeutic procedures (gastroplastic surgery, pacemaker implantation, and PTCA) during the follow-up period that may have been expected to reduce average in-hospital time per se.

Although this study focused on CVPD, data collection was limited to in-hospital-related health care consumption. Moreover, observation time was limited to 4 years for statistical reasons, although the major portion of the study group have remained on nCPAP therapy. It is likely that other additional benefits, in terms of reduced CVPD morbidity not addressed in this study, were gained. For instance, nCPAP treatment has been associated with a reduction of an elevated blood pressure (29–31) as well as a reduction of respiratory symptoms in bronchial asthma (33). Clearly, benefits that may reduce the need of secondary hospitalization should be taken into the final consideration when evaluating the overall impact on health associated with nCPAP treatment.

Only a few studies have addressed the cost–benefit aspects of reduction of morbidity after nCPAP in OSAS. Tousignant et al. (23) measured quality of health before and on nCPAP treatment using the standard gamble approach. A positive cost–utility ratio for nCPAP therapy was demonstrated in 19 patients after a mean treatment of 9.5 months. In addition, a quality of life analysis showed a favorable effect after nCPAP (23). The present findings enter yet another aspect in this cost–benefit perspective. Focusing only on CVPD, we found a considerable reduction of time spent in-hospital after initiation of successful nCPAP treatment, suggesting an extremely favorable effect of treatment in this aspect. It should be noted that a considerable proportion of the initially treated cohort had no registered CVPD or previous hospital records. In other words, the overall impact of nCPAP treatment on an unselected group of sleep apneics would be expected to result in a less pronounced average reduction of in-hospital care consumption. Nevertheless, our data confirms that there may be a definitely higher cost–benefit ratio to be achieved by treating sleep apnea patients with concomitant CVPD, a notion of particular importance whenever health resources are restricted and when imposing priority-based allocation of treatment.

Based on minimal daily hospital care cost, a minimal yearly health care consumption of Skr 414,000 (~US$ 60,800) was spent by the 19 nCPAP users before prescription compared to SKr 54,000 (~US$ 7,900) after, representing a total yearly saving of Skr 360,000 (~US$ 53,000). Considering all patients prescribed and using nCPAP, including patients with or without concomitant CVPD (n = 58), the total yearly cost of nCPAP devices amounted to approximately Skr 580,000 (~US$ 85,000). In view of the yearly saving in in-hospital care costs, this highlights the appropriateness of nCPAP allocation to OSAS patients with CVPD. Even if the total cost for in-hospital nCPAP level titration and control is considered, there is an evident cost–benefit associated with nCPAP treatment only in regard to reduced CVPD hospitalization costs after treatment initiation. However, this cost–benefit analysis does not include other potential beneficial effects of nCPAP treatment in OSAS such as reduction of hypersomnolence, reduced traffic-accident rate, reduction in sick leave, etc. In this wider perspective, cost–benefit of nCPAP treatment may be reached shortly after prescription in an unselected group of OSAS patients with or without CVPD.

It is concluded that long-term nCPAP treatment markedly reduces the need for acute hospital admission due to cardiovascular and pulmonary disease in patients with OSAS. This reduction of concomitant health care consumption should be taken into consideration when assessing the cost–benefit evaluation of nCPAP therapy.

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