Self-Reported vs Measured Compliance with Nasal CPAP for Obstructive Sleep Apnea*

Helmut Rauscher, M.D.; Dieter Formanek, M.D.; Wolfgang Popp, M.D.; and Hartmut Zwick, M.D., F.C.C.P.

To estimate reliability of self-reported compliance with nasal continuous positive airway pressure (CPAP) therapy for obstructive sleep apnea (OSA), we studied 63 OSA patients aged 53.7 ± 1.2 years (mean ± SEM) with an apnea hypopnea index (AHI) of 50.8 ± 2.9 and lowest sleep SaO₂ of 65.6 ± 2.3 percent receiving nasal CPAP for 539 ± 44 days. During a follow-up polysomnography (PSG) on the pressure prescribed for home therapy (10.3 ± 0.3 cm H₂O), the hours of operation shown on the built-in time counter of the patients’ devices were read to determine objective compliance by dividing the run time by the days since initiation of therapy. This parameter was compared with subjective compliance reported in a self-administered questionnaire. Mean measured use time was 4.9 ± 0.3 h per night, whereas reported daily use time calculated from reported nights a week and hours a night was 6.1 ± 0.3 h per night. As predominantly patients with poor compliance misestimated daily use time, we conclude that self-reports are unable to distinguish between compliant and noncompliant patients.

(Chest 1993; 103:1675-80)

**AHI = apnea hypopnea index; CPAP = continuous positive airway pressure; EDS = excessive daytime sleepiness; OSA = obstructive sleep apnea; PSG = polysomnography; SaO₂ = oxyhemoglobin saturation; Um = mean measured time of use per night; Ur = reported mean time of use per night; Uc = calculated subjective time of use per night**

Since its first description in 1981, nasal continuous positive airway pressure (CPAP) has become the first-line nonsurgical treatment for patients with obstructive sleep apnea (OSA). Although nasal CPAP quickly eliminates symptoms of OSA, above all excessive daytime sleepiness, long-term compliance may be a problem, despite the lack of serious side effects. Compliance with nasal CPAP has been studied extensively, and reported compliance rates range from 47 to 91 percent of patients. However, most of these studies are based solely on questionnaires or telephone interviews and only a few studies included objective data to estimate compliance, such as the hours of operation per night or the proportion of time mask pressure equals prescribed pressure.

This study was performed to determine possible discrepancies between self-reported and measured CPAP use and to find out the mode of data collection providing most reliable information on compliance from self-reports.

**METHODS**

**Patients**

We included 63 consecutive OSA patients (55 male, 8 female) prescribed nasal CPAP for a minimum of 3 months. At the time of the study, they were receiving nasal CPAP for 18 ± 1 months, with a wide range from 4 to 42 months. Mean age of our study population was 53.7 ± 1.2 years. During the initial study, apnea hypopnea index (AHI) was 50.8 ± 2.9, and lowest oxyhemoglobin saturation (SaO₂) was 65.6 ± 2.3 percent. Our subjects were moderately obese (body mass index [BMI] baseline: 32.3 ± 0.8) and did not lose weight until follow-up (BMI follow-up: 31.1 ± 0.7). Mean pressure prescribed for home therapy was 10.3 ± 0.3 cm H₂O. (Devices used by our patients were SleepEasy II, III, or REMStar [Respirronics, Inc]). None of our patients had concomitant serious disease that caused hospitalization during the study period.

Diagnosis of OSA was established by full-night polysomnography (PSG) with continuous registration of ECG, electro-oculography, submental electromyogram, EEG, air flow at nose and mouth (thermistors), movements of rib cage and abdomen (inductance plethysmography or strain gauges), and SaO₂. Sleep staging was done according to standard criteria. Apneas were defined as cessation of airflow at the nose and mouth for longer than 10 s. Hypopneas were defined as a reduction in rib cage and abdominal movements to 50 percent or less compared with the preceding five breaths for longer than 10 s accompanied by a fall in SaO₂ to 92 percent or lower if baseline was equal or above 94 percent or a fall in SaO₂ of 3 percent or more if baseline was 93 percent or lower.

The total number of apneas and hypopneas per hour of sleep represented the AHI. As part of clinical routine, all patients underwent follow-up PSGs on the pressure prescribed for home therapy every 6 months. The most recent sleep study, 539 ± 44 days after initiation of therapy, was used for this investigation. The prescribed pressure was still effective in reducing the AHI to less than 10 percent of the AHI on the initial study and preventing falls in SaO₂ during sleep below 90 percent in all of our patients. The hours of operation shown on the built-in time counter of the patients’ devices at the time of the last follow-up study were read by the sleep laboratory staff. By dividing the run-time shown on the time counter by the number of days since initiation of treatment, we calculated mean measured time of use per night (Um) and defined this as objective compliance.

Prior to the follow-up study, our patients answered a self-administered 35-item questionnaire on nasal CPAP therapy. This questionnaire included 14 questions on possible side effects of nasal...
CPAP. By assigning a point value from 1 to 5 to the answers never, seldom, sometimes, frequently, or always, we calculated a side effects score that was defined as the sum of all point values. In analogy, we calculated a score for daytime sleepiness (EDS score) on CPAP from the coded answers to these six questions: (a) Do you feel sleepy during daytime? (b) Do you fall asleep involuntarily when watching TV, (c) reading, (d) driving a car, (e) talking with others, (f) in boring situations like during conferences, movies, concerts, etc. As the same questions were also included in the questionnaire the patients completed prior to the initial study, we were able to estimate the subjective impression of efficacy of treatment.

To determine subjective compliance, we asked the following questions: (1) How many hours a night do you use nasal CPAP? (2) How many nights a week do you use nasal CPAP? (3) When do you usually go to sleep in the evening? (4) When do you usually put away your mask in the morning? (5) When do you usually get up in the morning? The answers to these questions enabled us to define three parameters indicating subjective compliance: Ue (estimated time of use per night) = reported hours of use per night; Ur (reported mean time of use per night) = interval between reported time of usually going to sleep and reported time of putting away the mask; and Uc (calculated subjective time of use per night) = reported hours of use per night times reported nights on CPAP per week divided by 7.

The interval between the reported times of going to bed and putting away the mask in the morning divided by the interval between the reported times of getting in and out of bed was used to estimate the proportion of bed time patients usually spend with nasal CPAP on.

Compliance with nasal CPAP was defined as a measured time of use of at least 4 h per night. To elucidate factors associated with noncompliance, we compared those 7 patients with the lowest Uc to the compliant group and excluded the intermediate group of 11 patients using their device more than 1.5 h but less than 4 h a night from this part of the analysis.

Results are given as means ± standard error (SEM). Correlations between parameters indicating subjective compliance and measured time of use per night were done by Spearman's rank test. For comparisons between groups as well as between results from the baseline and the follow-up study, Wilcoxon's signed rank test was used. Statistical significance was assumed below a p value of 0.05.

RESULTS

The frequency distribution of measured use times per night in our patients is given in Figure 1. As Um was above 4 h a night in 45 of our 63 patients, we found long-term compliance with nasal CPAP of 71 percent for a mean treatment period of 18 months. Mean measured time of use was 4.9 ± 0.3 h per night, with a wide range from 0.2 to 8.3. In contrast, our patients reported to use their CPAP device for 6.3 ± 0.2 nights a week and 6.5 ± 0.2 h a night, which theoretically would equal a mean use time of 6.1 ± 0.3 h a night. On the other hand, only 62 percent of our patients (39/63) reported using CPAP throughout sleep time and only 75 percent (47/63) stated to use it every night.

Comparisons between measured and reported use times are given in Figures 2 through 4. Although there were significant correlations between Um and reported use time regardless of the parameter used to determine subjective compliance, self-reports turned out as an inaccurate measure of nightly time of CPAP use for a significant part of our study population.

The majority of our patients overreported nasal CPAP use, and only a small group underreported treatment time per night. Comparing patients whose reported use time (Uc) was within ±20 percent of Um to patients misestimating nightly use time by more than 20 percent, we found that the latter used nasal CPAP for a shorter time per night (Table 1). Mean reported time in bed was 7.7 ± 0.2 h a night. Whereas the reported proportion of bed time spent with CPAP on was 90 ± 2 percent, calculating this percentage from time counter readings gave only 64.3 ± 3.3 percent. From the hours of use shown on the time counter, only 19/63 (30 percent) patients used their machine for more than 80 percent of their reported bed time, whereas from the reported interval between starting and stopping treatment in the course of an average night, 55/63 (87 percent) claimed to do so.

**Figure 1.** Frequency distribution of mean measured time of continuous positive airway pressure (CPAP) use per night (Um) in 63 patients with obstructive sleep apnea (OSA) treated for 539 ± 44 days.
Measured daily use time correlated only with lowest 
SaO_2 during the initial study (r = -0.26; p<0.05), but not with the number of respiratory events during 
sleep. There was a significant negative correlation 
between measured use time and the EDS score at 
follow-up (r = -0.31; p<0.05), but no correlation 
between compliance and the EDS score at initiation 
of therapy (r = -0.03), which in turn correlated with 
lowest SaO_2 during the initial study (r = -0.33; 
p<0.05), but not with AHI.

In accordance with other studies, we failed to 
find differences between compliant and noncompliant
patients with regard to prescribed pressure and PSG efficacy of nasal CPAP. As higher prescribed pressures were not associated with more frequent reports of side effects, troubles with nose and mask as well as difficulties initiating or maintaining sleep with CPAP on were of minor importance for compliance. However, as shown in Table 2, most of our patients had at least some problem with CPAP therapy.

Comparison among the seven noncompliant patients in our study population and the 45 patients using their device for more than 4 h a night revealed a tendency for the former toward less severe sleep apnea and higher side effects score (Table 3).

DISCUSSION

Despite significant correlations between measured and reported times of CPAP use per night, self-reports turned out to be an inaccurate tool to determine compliance with nasal CPAP therapy for OSA. Trying to estimate daily use time by simply asking how many hours a night the patient uses the device generally results in a considerable misestimation of actual mean treatment time per night because the patient is likely to provide the number of hours of CPAP use solely for the nights it was worn. As expected, including the question about the number of nights on CPAP per week makes self-reports of nasal CPAP use a bit more accurate. As treatment time may vary from night to night, the interval between the reported times of usually going to bed and putting away the mask is less accurate than nightly treatment time calculated from nights per week and hours per night, which appears to be the most reliable parameter to estimate nightly treatment time from self-reports.

Table 2—Reported Side Effects of Nasal CPAP (Percent of Study Population)*

<table>
<thead>
<tr>
<th>Side Effect</th>
<th>Frequently</th>
<th>Rarely</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mask leaves marks on face</td>
<td>48</td>
<td>37</td>
</tr>
<tr>
<td>Dry nose at night</td>
<td>30</td>
<td>40</td>
</tr>
<tr>
<td>Dry mouth in the morning</td>
<td>29</td>
<td>38</td>
</tr>
<tr>
<td>Congested nose during daytime</td>
<td>29</td>
<td>37</td>
</tr>
<tr>
<td>Difficulties initiating sleep</td>
<td>22</td>
<td>43</td>
</tr>
<tr>
<td>Red eyes</td>
<td>21</td>
<td>40</td>
</tr>
<tr>
<td>Ear discomfort</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Difficulties initiating sleep</td>
<td>3</td>
<td>27</td>
</tr>
<tr>
<td>Chest wall discomfort</td>
<td>0</td>
<td>33</td>
</tr>
<tr>
<td>Morning headache</td>
<td>0</td>
<td>33</td>
</tr>
<tr>
<td>Awakes gasping</td>
<td>0</td>
<td>16</td>
</tr>
</tbody>
</table>

*CPAP = continuous positive airway pressure.

Table 1—Characteristics of Patients With Measured Use Time (Um) Above and Below 80 percent of Reported Nightly Treatment Time (Uc)*

<table>
<thead>
<tr>
<th></th>
<th>Uc/Um&gt;0.8 (n=41)</th>
<th>Uc/Um&lt;0.8 (n=22)</th>
<th>p</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Um, h/night</td>
<td>6 ± 0.2</td>
<td>3.2 ± 2.4</td>
<td>&lt;0.0001</td>
<td>Value</td>
</tr>
<tr>
<td>Age, yr</td>
<td>53 ± 1.4</td>
<td>54.7 ± 2.4</td>
<td>0.5</td>
<td>0.2</td>
</tr>
<tr>
<td>AHI</td>
<td>54.6 ± 3.8</td>
<td>47.4 ± 4.2</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>Lowest sleep SaO₂, %</td>
<td>62 ± 3.3</td>
<td>68.8 ± 3.2</td>
<td>0.12</td>
<td>0.12</td>
</tr>
<tr>
<td>TIB, h</td>
<td>7.6 ± 0.2</td>
<td>7.7 ± 0.2</td>
<td>0.75</td>
<td>0.75</td>
</tr>
<tr>
<td>Days receiving CPAP</td>
<td>522 ± 51</td>
<td>600 ± 85</td>
<td>0.51</td>
<td>0.51</td>
</tr>
</tbody>
</table>

*AHI = apnea hypopnea index; TIB, time in bed; CPAP = continuous positive airway pressure
Our patients used their machines for 82 percent of the time they stated, which is somewhat higher than the 70 percent found by Reeves-Hoche et al. Part of the discrepancy between reported and measured use times may be attributed to not using the machine when traveling, during episodes of upper airway infection, or during self-prescribed treatment vacancies from time to time. Since preferentially patients with poor compliance overreported CPAP use, it is, however, unlikely that inaccurate reports were solely due to an unintentional error in estimating treatment time.

The finding that only 62 percent of our patients reported to use CPAP throughout sleep time is in accordance with our experience that most patients do not reestablish CPAP after the first awakening in the morning, eg, going to the bathroom, and spend the rest of the night without CPAP. From the results of a previous study, we suggest that they do have sleep apnea for this part of the night. Whereas the pathophysiologic consequences of this behavior are by no means clear, using CPAP for only part of the night usually does not result in recurrence of daytime sleepiness.

It may be argued that our measure of objective compliance does not reflect true treatment time but only the run-time of the blower. In fact, use of the blower for drying the tubes after washing may decrease reliability of time counter readings as a measure of treatment time, which may be a bit lower. However, by measuring the time mask pressure was within ±2 cm H_2O of prescribed pressure, it has been shown that patients do have their pressure for 93 percent of the device’s total run time. Having in mind that mask leaks contribute to this 7 percent difference, it is very unlikely that the discrepancies between subjective and objective compliance found in our study can be attributed to inadequacy of our measure for objective compliance. Furthermore, our patients’ machines had a total run time of 157,075 h, whereas the sum of run-times calculated from self-reports in our population was 191,255 h. Assuming that every patient used the blower 1 h per week for drying the tubes, this would result in an overestimation of the true treatment time by 4,846 h. As run-time for drying the tubes adds to treatment time, the discrepancy between reported and actual time of CPAP use would further increase from 18 to about 20 percent.

Defining compliance with nasal CPAP as a mean measured use time of more than 4 h per night, we found a compliance rate of 71 percent. Setting the limit for compliance to more than 3 h of use per night gave a compliance rate of 81 percent, which is somewhat lower than the 91 percent Krieger and Kurtz found with this criterion. In a recent study, 82 percent of patients reported “persistent but not necessarily daily use of nasal CPAP.” Another study found that 76 percent of patients “still used the device” after 14.5 months of treatment. Applying either of these definitions to our study population would have resulted in a compliance rate of 100 percent, because even the 18 patients in the noncompliant group reported using their machines for 5.5±0.4 h a night and 5.1±0.4 nights a week.

Aside from definition, the second major determinant of compliance found in a given study population is the mode of data collection. Most of the studies on compliance with nasal CPAP are based on questionnaires or telephone interviews. As compliant patients are more prone to return a questionnaire, self-selection of the study population may be a problem. Thus, compliance in a recent study ranged from 82 percent in repliers to 62 percent in nonrepliers who were contacted by telephone. The second problem with such studies—as shown herein—may be that reported compliance does not necessarily reflect actual compliance in at least part of the patients.

One of the few studies including objective data from the built-in time counter of the patient’s device found a mean use time of 5.14 h per night, which is very close to our 4.9 h. However, it is unclear whether mean treatment time per night actually corresponds to long-term benefit from CPAP therapy. To our knowledge, there are no studies comparing the outcome of patients using CPAP for the whole night and every night with that of patients using their device on an on-demand basis according to recurrence of daytime sleepiness.

Undoubtedly, the patient’s main motivation to sleep with a mask on the nose for the rest of his life is the impact daytime sleepiness from OSA has on his quality of life. However, the initial EDS scores of compliant and noncompliant patients were nearly equal. The failure of our initial EDS score to predict long-term compliance may be attributed to two factors. First, daytime sleepiness in OSA develops gradually and

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<tr>
<th>Table 3—Characteristics (Mean ± SEM) of Compliant (Um&gt;4h/Night) and Noncompliant Patients (Um&lt;1.5h/Night)*</th>
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<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>Um, h/night</td>
</tr>
<tr>
<td>Pressure</td>
</tr>
<tr>
<td>BMI</td>
</tr>
<tr>
<td>AHI</td>
</tr>
<tr>
<td>Lowest sleep SaO₂, %</td>
</tr>
<tr>
<td>EDS score baseline</td>
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<tr>
<td>EDS score follow-up</td>
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<tr>
<td>Side effects score</td>
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</tbody>
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*Um = measured use time; BMI = body mass index; AHI = apnea hypopnea index; EDS = excessive daytime sleepiness. 
†p<0.01 compared with EDS score baseline.
slowly. Thus, patients with OSA at the time of diagnosis may be unaware of the level of vigilance they could have without OSA and underreport EDS, resulting in a false low baseline score. Second, it may well be that such a score reflects EDS, but not how disabling EDS is for this particular patient. As the EDS score decreased more in the compliant group, in accordance with other studies, we suppose that severe EDS that resolves with nasal CPAP is a major determinant of long-term compliance.

Whereas impaired daytime vigilance in OSA may be attributed to sleep disruption reflected in the AHI as well as to nocturnal hypoxemia, the tendency to fall asleep involuntarily is more closely correlated with nocturnal hypoxemia than with the AHI. As only lower nadir SaO2 during the initial study, but not higher AHI, was associated with longer nightly use of nasal CPAP inability to stay awake in more or less boring situations appears to be subjectively more disabling—and by this associated with better compliance—than impairment of mental performance by EDS. However, long-term compliance was neither predictable from the degree of nocturnal hypoxemia nor from any combination of PSG or anthropometric features.

We conclude that most patients with OSA use nasal CPAP for a mean of more than 4 h a night. However, self-reports reflect actual compliance only in high users of CPAP, but they are unable to distinguish between compliant and noncompliant patients.

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