Outcome of Continuous Positive Airway Pressure Treatment with Suboptimal Pressure in Obstructive Sleep Apnea

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Continuous positive airway pressure is the treatment of choice for obstructive sleep apnea, and is highly effective especially in moderate-to-severe obstructive sleep apnea. Although continuous positive airway pressure treatment with optimal pressure is ideal, some patients undergo continuous positive airway pressure treatment with suboptimal pressure. We aimed to evaluate the treatment outcome of continuous positive airway pressure treatment with suboptimal pressure compared to that of diagnostic polysomnography, continuous positive airway pressure treatment with suboptimal pressure is effective to reduce mean apnea-hypopnea index to less than 5 only in 53.85% after 3 months of continuous positive airway pressure treatment, and 60% of patients after 6 months of continuous positive airway pressure treatment, respectively.

Key Words Obstructive sleep apnea, Continuous positive airway pressure, Treatment outcome, Pressure.
ary 2008 and March 2010 were enrolled in this study. All patients were treated with CPAP and followed for more than 3 months. The study protocol was reviewed and approved by the institutional review board.

Full PSG was performed at a neurology center. Procedures included electroencephalography (C3/A1, C4/A2, O1/A1, O2/A2); electro-oculography; electromyography of the chin and the anterior tibialis; electrocardiography; respiratory flow measurement (using a nasal cannula/pressure transducer); measurement of thoracic or abdominal movements (inductive plethysmography); and arterial oxygen saturation measurement (pulse oximetry). Apnea was defined as cessation of airflow for at least 10 sec, and hypopnea was defined as blood oxygen desaturation at 4% or greater and 30% reduction in airflow for more than 10 sec. The AHI was the number of apnea and hypopnea per hour of sleep. OSA was diagnosed when a patient had an AHI greater than 5, and symptoms of excessive daytime sleepiness, or an AHI greater than 15 regardless of daytime symptoms, in line with the 2007 American Academy of Sleep Medicine recommendations. Severity of OSA was judged from AHI data, and graded as mild OSA (5 ≤ AHI < 15/hr), moderate OSA (15 ≤ AHI < 30/hr), and severe OSA (AHI > 30/hr).

When a decision to use CPAP therapy was made, the optimal pressures for CPAP were determined by manual titration during the second night in the clinic. Titration pressure was classified as optimal titration pressure (RDI < 5/hr for at least 15-min duration, and included supine REM sleep at the selected pressure not continually interrupted by spontaneous arousals or awakenings), good titration pressure [10/hr ≤ RDI or 50% RDI reduction (baseline RDI < 15/hr) and included supine REM sleep at the selected not continually interrupted by spontaneous arousals or awakenings], and adequate titration pressure (RDI > 10/h but 75% RDI reduction, especially in severe OSA patients or one in which the titration criteria for optimal or good are met, with the exception that supine REM sleep did not occur at the selected pressure). Patients considering CPAP treatment tested a device for 1 month and before purchasing it.

The enrolled patients were divided into two groups: the optimal pressure group treated with optimal titration pressure, and the suboptimal pressure group treated with good or adequate titration pressure. The efficacy was evaluated using variables, particularly AHI recorded during domiciliary CPAP treatment after 3 and 6 months. The current analysis compared the optimal pressure group with suboptimal pressure group.

### Statistical Analysis

Statistical analyses were performed using SPSS software (Version 12.0, Statistical Package for Social Science, Chicago, IL, USA). The Mann-Whitney U test was used to determine the differences between the groups. The significance level was set at p < 0.05 for all analyses.

### RESULTS

There were 47 male and 6 female patients, with a mean age of 51.0 years (range 23 to 72 years). The mean follow-up time was 6.68 months (range 3 to 21 months). Among the patients, 33 were treated with optimal pressure and 20 were treated with suboptimal pressure, including 13 patients with good titration pressure and 7 patients with adequate titration pressure. The mean CPAP pressure was 8.45 ± 2.17 mmHg (range 4 to 14 mmHg). Baseline characteristics and diagnostic PSG values were similar in both groups (Table 1). During CPAP titration, mean AHI was 2.13 ±

### Table 1. Patient characteristics and polysomnographic findings

<table>
<thead>
<tr>
<th>Demographic variables</th>
<th>Optimal pressure group (n=33)</th>
<th>Suboptimal pressure group (n=20)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex (M : F)</td>
<td>31 : 2</td>
<td>16 : 4</td>
<td>0.184</td>
</tr>
<tr>
<td>Age (yrs)</td>
<td>49.58 ± 10.92</td>
<td>53.40 ± 12.39</td>
<td>0.104</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>170.79 ± 6.50</td>
<td>169.35 ± 5.90</td>
<td>0.388</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>79.12 ± 9.21</td>
<td>77.64 ± 16.16</td>
<td>0.339</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>26.87 ± 2.26</td>
<td>27.07 ± 4.06</td>
<td>0.446</td>
</tr>
<tr>
<td>Neck circumflex (cm)</td>
<td>40.52 ± 2.23</td>
<td>40.93 ± 3.60</td>
<td>0.839</td>
</tr>
<tr>
<td>Severity of OSA (mild : moderate:severe)</td>
<td>1 : 8 : 24</td>
<td>1 : 1 : 18</td>
<td>0.191</td>
</tr>
<tr>
<td>AHI (/hr)</td>
<td>37.03 ± 19.88</td>
<td>46.68 ± 16.74</td>
<td>0.093</td>
</tr>
<tr>
<td>Minimum SaO₂ (%)</td>
<td>78.78 ± 9.76</td>
<td>77.12 ± 7.30</td>
<td>0.470</td>
</tr>
<tr>
<td>Supine sleep time (min)</td>
<td>210.41 ± 97.52</td>
<td>221.26 ± 83.01</td>
<td>0.686</td>
</tr>
<tr>
<td>REM sleep time (min)</td>
<td>62.25 ± 27.36</td>
<td>71.17 ± 26.98</td>
<td>0.276</td>
</tr>
</tbody>
</table>

Values are expressed as mean ± standard deviation.
BMI: body mass index, PSG: polysomnography, OSA: obstructive sleep apnea, AHI: apnea-hypopnea index.
Outcome of Suboptimal CPAP Treatment in OSAS Patients

<table>
<thead>
<tr>
<th>Table 2. Mean AHI after CPAP treatment</th>
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<tr>
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<tr>
<td>During titration AHI (hr)</td>
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<tr>
<td>After 3 months AHI (hr)</td>
</tr>
<tr>
<td>After 6 months AHI (hr)</td>
</tr>
</tbody>
</table>

Values are expressed as mean ± standard deviation.
AHI: apnea-hypopnea index, CPAP: continuous positive airway pressure.

1.30/h in the optimal pressure group, 8.55 ± 4.66/h in suboptimal pressure group (p < 0.001). After 3 months of CPAP treatment, the mean AHI was reduced in both groups. The mean AHI was 2.85 ± 0.94/h in the optimal pressure group, 5.51 ± 3.42/h in suboptimal pressure group after 3 months of CPAP treatment (p = 0.012). Although mean AHI was reduced to less than 5 in all patients in the optimal pressure group, only 53.85% of patients showed reduction of mean AHI to less than 5 in the suboptimal pressure group. There was no significant difference in the incidence of central (3.16 ± 2.99 vs. 6.29 ± 12.35, p = 0.836) or obstructive apnea events (2.83 ± 2.31 vs. 4.57 ± 3.31, p = 0.534) during CPAP titration between patients who exhibited a mean AHI of less than 5, and a mean AHI greater than or equal to 5 after 3 months of CPAP treatment. After 6 months of CPAP therapy, the outcomes were similar with that after 3 months of CPAP treatment. The mean AHI was 2.38 ± 0.84/h in the optimal pressure group, and 5.33 ± 3.90/h in the suboptimal pressure group (p = 0.004). Mean AHI were reduced to less than 5 in 60% of patients with suboptimal pressure. These results were summarized in Table 2. Among the patients in the suboptimal pressure group, obstructive apnea events were more common in patients with an AHI greater than or equal to 5 after 6 months of CPAP therapy than in patients with AHI less than 5 (1.44 ± 1.81 vs. 6.83 ± 6.17, p = 0.014), but we could not find any significant difference in the incidence of central apnea events (3.89 ± 3.79 vs. 3.66 ± 4.27, p = 0.905).

DISCUSSION

The present study evaluated the treatment outcome of CPAP with suboptimal pressure in OSA. In our study, patients treated with optimal pressure experienced elimination of obstructive respiratory events, and the mean AHI was reduced to less than 5 during CPAP treatment for 3 and 6 months. On the other hand, in patients treated with suboptimal pressure, although mean AHI was reduced after 3 and 6 months of CPAP therapy compared to that of diagnostic PSG, not all the patients showed a mean AHI of less than 5 after 3 and 6 months of CPAP treatment, compared to patients treated with optimal pressure. CPAP treatment with suboptimal pressure is effective in reducing mean AHI to less than 5 only in 53.85% after 3 months of CPAP treatment, and 60% of patients after 6 months of CPAP treatment, respectively.

Since the original description of CPAP treatment by Sullivan et al. in 1981,6 CPAP treatment has been proved to be highly effective in treating OSA, leading to improvement in both subjective and objective daytime sleepiness as well as PSG values.7-10 CPAP titration is generally initiated during diagnostic PSG with the pressure level being titrated to eliminate obstructive respiratory events. There are numerous factors that can affect the pressure level of CPAP required to keep the upper airway patent during sleep. In general, supine position and REM sleep are situations that require the highest pressure.4 In one study, the optimal CPAP level was significantly higher in the supine position than it was in the lateral position in most patients who suffered OSA.11 Therefore, an ideal CPAP titration is one that demonstrates control of all respiratory events in supine REM sleep. Although no precise protocol for CPAP titration or optimal end point of titration exists, usually one starts at a pressure of 4 to 5 cm, gradually increasing by 1 to 2 cm every 15 to 20 minutes until obstructive apneas, hypopneas, respiratory effort-related arousals, oxygen desaturation and snoring are eliminated.12 However, it is not always possible to achieve the goal, which is to eliminate sleep pathophysiology. Although the pressure is high enough to eliminate all obstructive respiratory events, some patients could not continue to sleep due to the pressure itself, or CPAP-related CSA could appear during CPAP titration.4 CPAP-related CSA appears to represent a benign and transient phenomenon, and is likely related to sleep fragment and sleep stage shifts that occur with initial CPAP titration.13 This type of CSA occurs during NREM sleep, because Pao2 falls below the apneic threshold and tended to resolve with long-term CPAP treatment.14 Other possible reason for titration being suboptimal rather than optimal is that REM sleep did not occur during the best pressure because of medication-related REM suppression, inadequate REM sleep during sleep evaluation, and insufficient time for REM to occur late at night.15 Due to these reasons, it is not always possible to determine the optimal titration pressure, and lead to some patients undergoing CPAP treatment with suboptimal pressure.

The outcome of CPAP treatment with suboptimal pressure remains controversial and is not well established. If the titrated pressure is too low to abolish respiratory events, CPAP treatment is deemed ineffective. On the other hand, if suboptimal pressure titration is due to CPAP-related CSA, which is just a transient phenomenon during titration as mentioned above, highly effective improvement of sleep pathophysiology with suboptimal pressure is possible.

In our series, patients treated with suboptimal pressure and failed to reduce the mean AHI to less than 5 experienced more obstructive respiratory events during CPAP titration, compared to those who succeeded to reduce the mean AHI to less than 5.
after 6 months of CPAP therapy. This finding explains that suboptimal pressure level is inadequate to eliminate all obstructive respiratory events in some patients. In addition, we did not find difference between patients who failed to reduce mean AHI to less than 5, and those who succeeded to reduce the mean AHI to less than 5 in central apnea incidence during CPAP titration. Therefore, in our study, we could not explain the effect and outcome of CPAP related central apnea following CPAP treatment. Future studies are needed with large number of patients.

In conclusion, the outcome of CPAP treatment with suboptimal pressure may reduce the mean AHI in OSA patients, but not all obstructive respiratory events were effectively eliminated in all patients.

Conflicts of Interest
The authors have no financial conflicts of interest.

REFERENCES