online © ML Comm

BRIEF COMMUNICATION

ISSN 2093-9175
Sleep Med Res 2010;1:26-29

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

Jin-Young Min, MD, Ho Jun Lee, MD, Bong-Jae Lee, MD, Yoo-Sam Chung, MD, PhD

Department of Otolaryngology, Asan Medical Center, University of Ulsan College of Medicine, Seoul, Korea

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 with suboptimal pressure in obstructive sleep apnea. In this study, although mean apnea-hypopnea index was reduced after 3 and 6 months 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. **Sleep Med Res 2010;1:26-29**

Key Words Obstructive sleep apnea, Continuous positive airway pressure, Treatment outcome, Pressure.

INTRODUCTION

Continuous positive airway pressure (CPAP) is the treatment of choice for obstructive sleep apnea (OSA) and is highly effective particularly in moderate-to-severe OSA, defined as an apnea-hypopnea index (AHI) exceeding 15/h.[1,2] CPAP functions as a "pneumatic splint" by delivering an intraluminal pressure, thereby preventing the upper airway from collapsing during sleep in OSA.[3] Following diagnostic polysomnography (PSG), patients who meet the diagnostic criteria for OSA and is regarded as candidates for CPAP and undergo CPAP titration in the sleep laboratory. Although the optimal end point of titration has not been scientifically determined, most laboratories titrate to eliminate obstructive apnea, hypopnea, snoring, oxygen desaturation, and respiratory effort-related arousals.[4] The target AHI with CPAP treatment is usually between 5 and 10/h.[5] However, during positive pressure titration, it may be difficult to determine the optimal pressure in some patients. If the pressure is too low, it fails to eliminate obstructive apnea adequately, and if the pressure is too high, it could interfere the sleep itself. In addition, "CPAP-related central sleep apnea (CSA)" could appear during CPAP titration.[4] Due to these reasons, some patients inevitably undergo CPAP treatment with suboptimal pressure. To date, the efficacy of CPAP treatment with suboptimal pressure in OSA remains controversial. In this study, we aimed to evaluate the treatment outcome of CPAP with suboptimal pressure in OSA.

METHODS

Fifty-three (n = 53) patients diagnosed with OSA based on full PSG, tested with therapeutic PAP, and referred to the Asan Medical Center Snoring and Sleep Apnea Clinic between Janu-

Received: September 1, 2010
Revised: October 20, 2010
Accepted: October 22, 2010

Correspondence
Yoo-Sam Chung, MD, PhD
Department of Otolaryngology,
Asan Medical Center,
University of Ulsan College of Medicine,
86 Asanbyeongwon-gil, Songpa-gu,
Seoul 138-736, Korea
Tel +82-2-3010-3716
Fax +82-2-489-2773
E-mail yschung@amc.seoul.kr

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 ($5 \leq$ AHI < 15/hr), moderate OSA ($15 \leq$ 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 $\leq$ 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 characterisitics and polysomnographic findings

	Optimal pressure group (n=33)	Suboptimal pressure group (n=20)	p-value
Demographic variables			
Sex (M : F)	31 : 2	16 : 4	0.184
Age (yrs)	49.58 ± 10.92	53.40 ± 12.39	0.104
Height (cm)	170.79 ± 6.50	169.35 ± 5.90	0.388
Weight (kg)	79.12 ± 9.21	77.64 ± 16.16	0.339
BMI (kg/m^2)	26.87 ± 2.26	27.07 ± 4.06	0.446
Neck circumflex (cm)	40.52 ± 2.23	40.93 ± 3.60	0.839
PSG variables			
Severity of OSA (mild : moderate:severe)	1 : 8 : 24	1 : 1 : 18	0.191
AHI (/hr)	37.03 ± 19.88	46.68 ± 16.74	0.093
Minimum SaO_2 (%)	78.78 ± 9.76	77.12 ± 7.30	0.470
Supine sleep time (min)	210.41 ± 97.52	221.26 ± 83.01	0.686
REM sleep time (min)	62.25 ± 27.36	71.17 ± 26.98	0.276

Values are expressed as mean ± standard deviation.
BMI: body mass index, PSG: polysomnography, OSA: obstructive sleep apnea, AHI: apnea-hypopnea index.

Table 2. Mean AHI after CPAP treatment

	Optimal pressure group (n = 33)	Suboptimal pressure group (n = 20)	p-value
During titration AHI (/hr)	2.13 ± 1.30	8.55 ± 4.66	0.000
After 3 months AHI (/hr)	2.85 ± 0.94	5.51 ± 3.42	0.012
After 6 months AHI (/hr)	2.38 ± 0.84	5.33 ± 3.90	0.003

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 $Paco_2$ falls below the apneic threshold and tended to resolve with long-term CPAP treatment.[4,14] 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

1. Barbé, Pericás J, Muñoz A, Findley L, Antó JM, Agustí AG. Automobile accidents in patients with sleep apnea syndrome. An epidemiological and mechanistic study. *Am J Respir Crit Care Med* 1998;158:18-22.
2. Kapur VK, Redline S, Nieto FJ, Young TB, Newman AB, Henderson JA; Sleep Heart Health Research Group. The relationship between chronically disrupted sleep and healthcare use. *Sleep* 2002;25:289-96.
3. Abbey NC, Cooper KR, Kwentus JA. Benefit of nasal CPAP in obstructive sleep apnea is due to positive pharyngeal pressure. *Sleep* 1989;12:420-2.
4. Kakkar RK, Berry RB. Positive airway pressure treatment for obstructive sleep apnea. *Chest* 2007;132:1057-72.
5. Meurice JC, Paquereau J, Denjean A, Patte F, Series F. Influence of correction of flow limitation on continuous positive airway pressure efficiency in sleep apnoea/hypopnoea syndrome. *Eur Respir J* 1998;11:1121-7.
6. Sullivan CE, Issa FG, Berthon-Jones M, Eves L. Reversal of obstructive sleep apnoea by continuous positive airway pressure applied through the nares. *Lancet* 1981;1:862-5.
7. Barnes M, Houston D, Worsnop CJ, Neill AM, Mykytyn IJ, Kay A, et al. A randomized controlled trial of continuous positive airway pressure in mild obstructive sleep apnea. *Am J Respir Crit Care Med* 2002;165:773-80.
8. Gay P, Weaver T, Loube D, Iber C; Positive Airway Pressure Task Force; Standards of Practice Committee; American Academy of Sleep Medicene. Evaluation of positive airway pressure treatment for sleep related breathing disorders in adults. *Sleep* 2006;29:381-401.
9. Kushida CA, Littner MR, Hirshkowitz M, Morgenthaler TI, Alessi CA, Bailey D, et al. Practice parameters for the use of continuous and bilevel positive airway pressure devices to treat adult patients with sleep-related breathing disorders. *Sleep* 2006;29:375-80.
10. Loube DI, Gay PC, Strohl KP, Pack AI, White DP, Collop NA. Indications for positive airway pressure treatment of adult obstructive sleep apnea patients: a consensus statement. *Chest* 1999;115:863-6.
11. Oksenberg A, Silverberg DS, Arons E, Radwan H. The sleep supine position has a major effect on optimal nasal continuous positive airway pressure : relationship with rapid eye movements and non-rapid eye movements sleep, body mass index, respiratory disturbance index, and age. *Chest* 1999;116:1000-6.
12. Chowdhuri S. Continuous positive airway pressure for the treatment of sleep apnea. *Otolaryngol Clin North Am* 2007;40:807-27.
13. Dernaika T, Tawk M, Nazir S, Younis W, Kinasewitz GT. The significance and outcome of continuous positive airway pressure-related central sleep apnea during split-night sleep studies. *Chest* 2007;132:81-7.
14. Guilleminault C, Cummiskey J. Progressive improvement of apnea index and ventilatory response to CO2 after tracheostomy in obstructive sleep apnea syndrome. *Am Rev Respir Dis* 1982;126:14-20.
15. Teofilo Lee-Chiong. Positive Airway Pressure Therapy for Obstructive Sleep Apnea. *Sleep Medicine Clinic* 2006;1:527-31.