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MISCELLANEOUS

Does nasal congestion have a role in decreased resistance to regular CPAP usage?

Ayşe İriz[1] · Mehmet Düzlü[1] · Oğuz Köktürk[2] · Yusuf Kemal Kemaloğlu[1] · Fakih Cihat Eravcı[1] · Mehmet Ekrem Zorlu[1] · Recep Karamert[1]

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Abstract Nasal obstruction is known to cause resistance to continuous positive airway pressure (CPAP) therapy in obstructive sleep apnea syndrome (OSAS). In this paper, short- and long-term nasal congestion in OSAS patients receiving CPAP treatment were evaluated with acoustic rhinometry (AR). A total of 36 patients with moderate-to-severe OSAS, diagnosed with polysomnography were included in the study. Ten healthy subjects without OSAS constituted the control group. Pre-treatment nasal patency were measured with AR in all participants. 26 patients used the recommended CPAP treatment. Ten patients did not accept CPAP treatment. The AR test was repeated for all the subjects after 1 and 3 months except the 3rd month's measurements of the control group. There was no statistically significant difference between the initial minimum cross-sectional area (MCA) measurements of OSAS patients, using or not using CPAP, and the control group ($P > 0.05$). However, the first month MCA measurements of patients receiving CPAP were found to be significantly decreased compared with the initial values ($P < 0.001$). There was no significant change in the first and third months MCA values in the control group and patients who did not use CPAP ($P > 0.05$). No significant difference revealed in the 3rd month MCA measurements of the patients using CPAP compared with the initial values ($P > 0.05$). In this study, the increased nasal congestion, which is thought to be the cause of CPAP resistance, was objectively demonstrated in OSAS patients using CPAP. In addition, the nasal congestion developing at the first month was shown to disappear over time, supporting the opinion that patient compliance in CPAP treatment is expected to increase after regular device usage.

Keywords OSAS · CPAP · Acoustic rhinometry

Introduction

The role of nose in obstructive sleep apnea syndrome (OSAS) pathophysiology is still controversial. In many studies, differences in nasal passage have been shown in OSAS patients compared to control groups [1–3].

Continuous positive airway pressure (CPAP) is the most preferred treatment modality for moderate-to-severe OSAS for a long time. CPAP treatment has been shown to effectively reduce sleep-related respiratory disturbances and possible complications of OSAS [4]. However, the upper airway occlusion, which is important in determining the critical titration pressure, is still a challenging problem [5].

Nasal airway is also an important factor in the efficacy of CPAP therapy. The cause of sub-clinical nasal inflammation has not yet been fully explained [2, 3]. In addition, nasal congestion is thought to be one of the main causes of CPAP treatment resistance [1]. Consequently, some patients discontinue the CPAP therapy at the beginning of the treatment [3]. The duration of this nasal congestion has not yet been shown.

The aim of this study is to demonstrate nasal congestion with acoustic rhinometry (AR) test in OSAS patients using CPAP and to identify alterations in nasal congestion with the use of long-term effective CPAP therapy.

✉ Mehmet Düzlü
mehmetduzlu@gmail.com

[1] Department of Otorhinolaryngology and Head and Neck Surgery, Faculty of Medicine, Gazi University, Beşevler, 06500 Ankara, Turkey

[2] Department of Pulmonary Disease, Faculty of Medicine, Gazi University, Ankara, Turkey

Materials and methods

Study design

The study was conducted at the departments of Otorhinolaryngology and Chest Diseases of Gazi University Faculty of Medicine. The approval was taken from local ethics committee. All patients were selected from the subjects undergoing PSG testing after anamnesis and clinical examination. The study group consisted of 36 patients with moderate-to-severe OSAS. Ten healthy individuals without OSAS constituted the control group. CPAP therapy was offered for all patients with OSAS, but only 26 patients accepted. The remaining ten patients were included in the study by providing conservative treatment options. A complete otolaryngologic examination, flexible endoscopic examination and Muller test were performed on the patients and control group. Patients with marked nasal pathology and/or rhinosinusitis were excluded. Epworth sleepiness scale questionnaire was applied to all patients. The demographic and the polysomnographic data of the subjects including, age, sex, body mass index (BMI), apnea–hypopnea index (AHI), mean oxygen scores and hypoxia percentages were recorded.

Polysomnography

Subjects underwent all-night polysomnography and optimal CPAP-level titration. All-night polysomnography was performed by trained professionals using the Grass Technologies Twin Copyright 1995–2017 version 4.5–3.23 (Natus Medical Incorporated Fabrica, Ontario/Canada, made in USA) Biological variables were measured by electroencephalography (C3/A2, C4/A1, O1/A2, O2/A1), bilateral electrooculography, submentonian and anterior tibial electromyography, and electrocardiography (V2 modified). Oral and nasal flows were measured with a thermistor and nasal cannula with a pressure transducer, respectively. Thoracic and abdominal movements were monitored by non-calibrated inductance plethysmography, snoring was recorded using a microphone, oxyhemoglobin was measured by pulse oximetry, and body position was monitored by a sensor. The AHI was calculated, and we also obtained other polysomnographic data such as Apnea Index (AI), lowest saturation, percentage in non-rapid eye movement (NREM) versus REM states, and central apnea.

OSAS patients were randomly selected from the patients with AHI above 20. The control group was selected from the subjects with AHI below five by randomization as well.

Acoustic rhinometry

In this study, nasal patency was evaluated using Acoustic Rhinometry (Rhinometrics Rhinometer version SRE 2000). This procedure allows for measurement of the cross-sectional area (cm^2) and volume (cm^3) of the nasal cavity. The measurements included in the analysis were the lowest values of at least two reproducible curves. The cross-sectional area (cm^2) was obtained along the nasal pit in centimeters, indicating the main bottle neck areas, and this measurement was used to assess the mean minimal cross-sectional area (MCA) of bot nasal pits: 0 and 22 mm from the nostril, which seemed to correspond to the nasal valve (MCA 1), and 22–54 mm from the nostril (MCA 2). The same parameters were used to determine the volume, with volume 1 (vol. 1) being between 0 and 22 mm and volume 2 (vol. 2) being between 22 and 54 mm [1].

We used the mean values of MCA 1 and MCA 2, to evaluate the both of OSAS groups and control cohorts in our study. AR measurements were taken at the beginning and repeated at the end of the first and third month for two groups of patients with moderate-to-severe OSAS who did and did not use CPAP. A healthy control group were tested at the beginning and repeated only at the end of the first month. Each group was compared within themselves based on the measurements of initial, first and third months. Additionally, inter-group initial measurements were compared.

Statistical analysis

Mean values of the participants were determined using the SPSS version 20. Age, AHI, mean pO_2 values, hypoxia percentages, Epworth sleepiness scale outcomes and initial AR measurements were compared between the groups using the Tukey corrected one-way ANOVA test. AR measurements of the OSAS patients who used and did not use CPAP and the control group were analyzed separately using the General Linear Model for repeated measures. Pillai's test was used to determine the *P* value when we obtain significant statistical results at Mauchly's Sphericity test (Table 2). When we found significant statistical difference in recurrent AR measurements, paired-samples *t* test was used to determine the actual visit time that results in significant difference in Group 1 patients (Table 1).

Results

Forty-six subjects, 16 females and 30 males, were included in the study. Of these, 26 subjects constitute the moderate-to-severe OSAS group using CPAP with a mean age of 52 ± 6.9 and ten subjects constitute the moderate-to-severe OSAS group who did not use CPAP with a mean age of 56 ± 9.2 years. The mean age of the control group was 40 ± 7.4 years. There was no statistically significant difference in terms of age, BMI, AHI, mean pO_2 values, hypoxia percentages, and Epworth sleepiness scale questionnaire

Table 1 Evaluation of repeated Acoustic Rhinometry measurements (MCA1 and MCA2) within groups

Group	MCA1				MCA2			
	0 month	1 month	3 months	*P* value	0 month	1 month	3 months	*P* value
1. OSAS + CPAP	1.06 ± 0.04	0.9 ± 0.11	1.05 ± 0.03	< 0.001	0.76 ± 0.17	0.61 ± 0.18	0.79 ± 0.16	< 0.001
2. OSAS	1.03 ± 0.03	1.02 ± 0.03	1.03 ± 0.03	0.218	0.63 ± 0.1	0.63 ± 0.05	0.63 ± 0.04	0.368
3. Control	1.03 ± 0.18	1.03 ± 0.17	–	0.168	0.68 ± 0.1	0.67 ± 0.1	–	0.108

P values = repeated measures multivariate analisies − Pillai's test are expressed as mean ± standard deviation

MCA minimum cross-sectional area

Table 2 Monthly comparison of repeated acoustic rhinometry measurements in Group 1 (OSAS patients receiving CPAP therapy) patients

	Mean ± SD	Mean ± SD	*P* value
MCA 1 (cm^2)			
0–1 month	1.06 ± 0.06	0.9 ± 0.11	< 0.001
0–3 months	1.06 ± 0.06	1.05 ± 0.03	0.243
1–3 months	0.9 ± 0.11	1.05 ± 0.03	< 0.001
MCA 2 (cm^2)			
0–1 month	0.76 ± 0.17	0.61 ± 0.18	< 0.001
0–3 months	0.76 ± 0.17	0.79 ± 0.16	0.136
1–3 months	0.61 ± 0.18	0.79 ± 0.16	< 0.001

P values = paired-samples *t* test are expressed as mean ± std. deviation

MCA (cm^2) minimal cross-sectional area

results between two OSAS patient groups ($P > 0.05$). The age, BMI and AHI of control group without OSAS were significantly lower than the two OSAS groups ($P < 0.05$).

The initial MCA1 and MCA2 values measured by the AR test were compared between the three groups and no significant difference was observed statistically ($P > 0.05$). The measurements of each groups at different visit times were evaluated. There was significant difference between initial, first month and third month's MCA 1 and 2 values of OSAS patients receiving CPAP treatment ($P < 0.001$ for MCA 1 and 2). However, there was no statistically significant difference between initial MCA 1 and 2 measurements compared with first month and third month's MCA 1 and 2 measurements in the OSAS group who did not use CPAP ($P = 0.218$ for MCA 1, $P = 0.368$ for MCA 2). Likewise, there was no statistically significant difference between initial and first month's MCA 1 and 2 values in the control group without OSAS disease ($P = 0.168$ for MCA 1 $P = 0.108$ for MCA 2) (Table 1).

The significant difference revealed in nasal patency in Group 1 (OSAS patients receiving CPAP treatment) patients were further analyzed. After receiving CPAP treatment, a statistically significant decline in the MCA 1 and 2 values were found compared with the initial values, at the end of first month ($P < 0.001$ for MCA 1 and 2). The MCA 1 and 2 values at the first month and MCA 1 and 2 at the third month were also significantly different ($P < 0.001$ for MCA 1 and 2). However, no statistically significant difference revealed between initial and third month's MCA 1 and 2 values in this group ($P = 0.243$ for MCA 1, $P = 0.136$ for MCA 2) (Table 2).

Discussion

There are many studies in the literature based on the relationship between OSAS and nasal obstruction, but the relationship between them is not fully understood. A number of pathophysiological mechanisms can potentially explain the role of nasal pathology in OSAS. These include the Starling resistor model, the unstable oral airway, the nasal ventilatory reflex and the role of nitric oxide (NO) [6–8]. In our study, there was no significant difference between initial cross-sectional nasal cavity areas of two study groups consisted of CPAP user and non-CPAP user OSAS patients and control group based on AR measurements.

The main treatment modalities of OSAS include surgical treatments and PAP therapy. CPAP therapy is the main treatment modality, especially for moderate to severe OSAS. As the diagnosis rate of the disease increases, the number of patients treated with CPAP is also increasing [4]. The rate of adherence to CPAP therapy is less than 70% [9]. Over 50% of CPAP users complain of significant nasal symptoms. One of the main problems that make treatment adjustment difficult in CPAP treatment is thought to be nasal mucosal edema and inflammation [6, 10, 11]. Numerous physiological and pathological studies have been carried out in the literature evaluating nasal resistance in CPAP users. For this purpose, acoustic rhinometry and rhinomanometry measurements and pathological examinations are commonly used methods [5, 12, 13]. Many studies have shown an increase in nasal resistance, nasal mucosal narrowing, and increased mucosal inflammation in patients using CPAP [1–3]. In most of the studies, patients with moderate-severe OSAS who used CPAP were compared with the control group with mild OSAS who did not use CPAP. In our study, nasal mucosal reactions of patients with moderate-to-severe OSAS group

using CPAP were compared with moderate-to-severe OSAS patients who did not want to use CPAP and with the healthy control group who did not suffer OSAS. Thus, the possible effect of the disease and all other factors were excluded and the effect of PAP treatment could be demonstrated directly.

Acoustic rhinometry is an objective test method that measures nasal passage area and volume with proven efficacy. This test was used in previous studies to measure nasal congestion in patients using CPAP [4]. In our study, 26 patients who used CPAP and 10 patients who did not use CPAP therapy were compared in terms of AHI, mean oxygen saturation and hypoxia percentage. All the patients in these two groups were suffering moderate-to-severe OSAS who did not have a significant difference in terms of age, sex and BMI. No statistically significant difference was observed between them.

The MCA (cm^2) was measured at two different levels from the right and left nasal cavity at the beginning of the study and at the end of the 1st and 3rd months with AR test. No statistically significant difference was found between all three groups at initial nasal passage measurements. This result has shown that there is no significant difference between nasal passages of OSAS patients and non-OSAS control group (Table 1). In addition, at the end of the first month, a statistically significant reduction revealed in nasal cavity cross-sectional areas of the patients with severe OSAS using CPAP. At the end of the 3rd month, narrowing of the nasal passages was regressed and no statistically significant difference revealed between the 3rd month measurements and the initial measurements of CPAP patients. No significant differences were found between the first and third month results of the other groups (Table 2).

Gelardi et al. [2] cytologically demonstrated that regular CPAP use reduces inflammation in the nasal mucosa at long term. Likewise, in our study, the regular CPAP use has been shown to reduce the reactional narrowing in the nasal passage over time, by means of physiological testing with AR.

Conclusion

In this study, the diameters of nasal passage of the CPAP users were objectively compared with those of non-CPAP user OSAS patients and healthy control subjects for the first time in the literature. This study objectively showed the effect of CPAP on nasal patency by comparing OSAS patients who used or did not use CPAP therapy. The nasal congestion due to regular use of CPAP was profound in the first month, which supports the common opinion that resistance to CPAP therapy is mostly seen in the first few months. In addition, this acute reaction was observed to regress in long term after stable and regular CPAP use. These results suggest that short-term cautions for nasal congestion at the onset of CPAP therapy is critical and sufficient for the continuity of treatment.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all individual participants included in the study.

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