ORIGINAL ARTICLE

Impulse Oscillometry in Obstructive Sleep Apnea Syndrome

Babak Amra , Fahimeh Sheikh Bahaee, Ziba Faraj Zadegan, Mohammad Golshan

Department of Medicine, Isfahan University of Medical Sciences, Iran

Indian J Sleep Med 2007; 2.4, 126-129

Abstract

Question of Study: In this study, we examined the oral airway resistance during wakefulness in different degrees of severity of OSAS (Obstructive sleep apnea) with Impulse Oscillometry and investigated whether these changes have any correlation with sleep apnea severity parameters.

Methods: All subjects who were admitted in sleep lab to undergo overnight sleep study were enrolled. Pulmonary function testing and measurement of oral airway resistance [resistance (R) and reactance (X)] by Impulse Oscillometry were done for every subjects. The average number of episodes of apnea and hypopnea per hour of sleep (the apnea-hypopnea index, AHI) were calculated. An AHI of 5 –29 represented mild/moderate OSAS and an AHI ≥30 represented severe OSAS.

All parameters were compared between controls and mild/moderate and severe OSAS groups by using one way ANOVA methods.

Results: Patients with severe OSA had significantly lower FVC ($P < .05$) than healthy subjects; however, the values were within the normal range. Also these Patients had a higher resistance at 5 Hz ($P < .05$) and lower reactance than control($P < .05$) .

Conclusion: Impulse oscillometry data may be good predictor of OSA in Iranian patients with sleep apnea.

Keywords: Obstructive sleep apnea syndrome – Oral airway resistance – impulse oscillometry

Introduction

Obstructive sleep apnoea (OSA) is a serious and potentially life-threatening disorder , with excessive daytime sleepiness and loud snoring during sleep being the principal symptoms. OSA arises from a combination of pathophysiological and anatomical factors resulting in the narrowing of the upper airway at the level of the pharynx.(1)

During nasal breathing, the nasal passages constitute the relevant upstream inspiratory resistor, whereas during mouth breathing the oral cavity is the site of upstream resistance. Resistance to airflow through the oral cavity is a major component of total upper airway resistance during oral and oronasal breathing. (2) Mouth breathing occurs during sleep, even in normal subjects, and may be increased during sleep-disordered breathing events. (3)

Total upper airway resistance, nasal resistance and pharyngeal resistance have all been studied extensively in OSAS.(3) They can be measured directly or indirectly by many methods.

Impulse oscillometry (IO) is an easier non invasive method to assess airway's resistance, this method has been used for assessment of airflow obstruction during CPAP in patients with sleep apnea (4), but a universal agreement of the relationship between airway resistance by impulse oscillometry and OSA is currently lacking.

Babak Amra
Sheikh Mofid St, 8164763831, Isfahan, Iran
Email: amra@med.mui.ac.ir
Fax: 00983116623967, TEL: 00983116637177

The purpose of this study is to evaluate the airway resistance by impulse oscillometry in Iranian patients with obstructive sleep apnea syndrome.

Materials and Methods

Selection of Subjects

Ethical approval for this study was obtained from the Isfahan university of medical sciences Research Ethics Committee.

All subjects who were admitted in sleep lab to undergo overnight sleep study were enrolled . Patients were excluded if there was any history or clinical evidence of primary central nervous system, systemic, or neuromuscular diseases, or if they had evidence of acute infection within 1 month prior to the study. Control group consisted of 104 healthy controls. mild to moderate OSA group consisted of75 patients and severe OSAS group consisted of 31 patients proven by an overnight sleep study.. Prior to the procedure. All subjects underwent simple spirometry and impulse oscillometry.

Polysomnography

Overnight PSG was performed in all patients by a computerized system and included the following variables: electroencephalogram, electro-occulogram, submental and leg electromyograms, electrocardiogram, and airflow (with an oronasal thermistor). Chest and abdominal efforts were recorded by using inductive plethysmography, arterial oxyhemoglobin saturation by pulse oximetry with a finger probe. Snoring sound was recorded with a microphone attached to the neck. All variables were recorded by using an 18-channel polysomnograph (Somnologica , Medcare, Netherland). Sleep stages were scored according to the standard criteria of Rechtschaffen and Kales.(5) Apneas were defined as complete cessation of airflow ≥10 seconds and hypopneas as a reduction in oronasal airflow of >50% lasting for 10 seconds. The apnea-hypopnea index (AHI) was defined as the number of apneas and hypopneas per hour of sleep. Patients were grouped by their total AHI. These groups were mild/moderate OSAS—AHI 5–29.9 and severe OSAS—30 (6).

Pulmonary Function Tests

Pulmonary function tests (PFT) were performed prior to entry into the study using a using standard spirometry (VIASYS Healthcare GmbH, Germany) with the subjects in a sitting position. The FEV1, FVC and FEV1/FVC ratios were recorded.. The detailed protocol of lung function measurements and instruments of this study have been described previously.(7)

Forced Oscillation Technique (FOT)

The equipment used for impulse oscillometry (IOS Jaeger, Würtzburg, Germany) consisted of an impulse generator (a loudspeaker), a pneumotachograph, and a pressure transducer. The impulse interval was set at the default level of 0.33 seconds with a pulse length of 45 ms. The superimposed pressure oscillations during normalvolume spontaneous breathing are composed of several frequencies, allowing the assessment of resistance and reactance at several frequencies simultaneously. The frequency range of the signal was from 0 to 30 Hz, and we recorded R and X at 5 and 25 Hz. (8)

Data Analysis

Statistical analysis was performed by using a SPSS version 15.0 statistical program (SPSS, Inc., Chicago). Anthropometric information was derived from frequency tables , one-way ANOVA was used for comparisons between the control group, the mild/moderate OSAS group, and the severe OSAS group.

All parametric results were expressed as mean ± SD for each group. Local statistical significance was assumed as $P < .05$ for all parameter.

Results

All parameters of patients are summarized in (Table).

104 subjects were in control group . Seventy –five patients were in the mild/moderate OSAS group, with an AHI value of 5–29.9; 31 patients were in the severe OSAS group, with an AHI 30

Mean (SD) ages were 41.5 (15.3) years and 50.5 (13.6) years and 56.8 (10.4) years in Control, mild to moderate OSAS and severe OSAS Subjects respectively.

Patients with severe OSAS had significantly greater airway resistance ($P = .023$).

In addition, patients with severe OSAS had significantly higher mean BMI, neck circumference than did the control group ($P = .000$). Although there was no

Table 1: Parameters of patients according to stages of OSAS and control group

Parameters	Control Group (n =104) (mean ± SD)	Mild/Moderate OSAS (n =75) (mean ± SD)	Severe OSAS (n = 31) (mean ± SD)	P* Value
Age (y)	41.5± 15.3	50.5± 13.6	56.8± 10.4	0.000
BMI (kg/m^2)	26.2± 5.6	30.1± 6.5	35.1± 7.7	0.000
Neck circumference (cm)	36.6± 4.3	39.8± 5.1	41.3±4.6	0.000
AHI	1.78± 1.5	13.03± 6.1	56.3± 17.9	0.000
FEV1, % predicted	88.02± 17.5	89.1± 18.9	80.8± 19.8	0.1
FVC, % predicted	90.5± 16.3	90.8± 17.	80.7± 18.3	0.03
FEV1/FVC	81.7± 10.5	80.1± 8.4	81.4± 10.05	0.5
R5	0.5± 0.35	0.53± 0.42	0.76± 0.59	0.023
R25	0.35 ± 0.25	0.34± 0.21	0.42± 0.2	0.3
X5	-0.12± 0.18	-0.09± 0.16	-0.24± 0.46	0.02
X25	-0.05± 0.18	-0.009± 0.19	-0.07± 0.17	0.17

Note.—OSAS indicates obstructive sleep apnea syndrome; AHI, apnea-hypopnea index;

· Compared by using the one-way ANOVA. Significant values are shown in boldface.

As has shown in table (1) there are significant differences in FVC, R5and X5 between three groups.

statistical difference in FEV1,FEV1/FVC,R25and X25 between the groups.

Discussion

IO had been used routinely to evaluate respiratory function in a variety of clinical situations, including testing airway responsiveness to inhaled agents (bronchoprovocation and bronchodilatation) and monitoring respiratory resistance during invasive and noninvasive mechanical ventilation.(9) Navajas et al, made significant contributions to the use of IO to measure lung function during sleep and evaluate upper airway obstruction in OSA patients (9,10). They used IO as an unobtrusive way to quantify the degree of airway obstruction during sleep, avoiding interference with sleep. They found that airway resistance changes found in OSA patients during sleep are mainly due to variations in upper airway resistance. IO has adequate time resolution to track obstructive events in the upper airway during the different phases of the breathing cycle. airway resistance is high during inspiration and low during expiration, indicating a closed and open upper airway, respectively. airway resistance measured by IO is an index of airflow obstruction that is useful both for diagnosing OSAand for titrating optimal CPAP treatment (10).

Despite the fact that we found a positive correlation between AHI and the resistance of the respiratory system in quiet tidal breathing, and also a gradual (statistically non significant) increase of the mean resistance of the respiratory system from control group to patients with severe OSAS, all the differences persist when controlled for age.

Our results are not consistent with previous studies such as the study of Amis et al(11) They measured inspiratory oral airway resistance to airflow in 13 awake OSAS patients and found a normal AR of the upright

position, but an abnormally high AR in the supine position. Kawano et al. had similar findings. (12)

Difference in our studies may be due to ethnicity factor or use of larger sample size that we used.

In most the studies, however, OSAS patients had significantly higher BMI and larger neck size than did normal subjects (13,6). In our study, there were significant differences among each group according to BMI, but patients with severe OSAS had significantly larger neck circumference than did other groups. We also found positive correlation between neck circumference and AHI, as reported elsewhere.(13)

In severe OSAS, patients had significant differences in the parameters. These parameters were age , body mass index , neck circumference ,FVC, R5,X5.Of these parameters, the measurement of airway resistance by impulse oscillometry can be a helpful diagnostic measure to recognize severe OSAS as a new key point. Further dynamic studies with larger series are necessary to determine the relationship between severity of OSAS and airway resistance by impulse oscillometry.

Acknowledgements

The authors cordially acknowledge the partial grants from

1- Bamdad Respiratory Research institute

2- Isfahan university of medical sciences

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