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Predictors for Presence and Severity of Obstructive Sleep Apnea in Snoring Patients: Significance of Neck Circumference

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Objectives: Documented risk factors for obstructive sleep apnea include advanced age, male gender, hypertension, large neck circumference, and obesity; but some controversy remains regarding the risk factors, especially in Asians. In this study, we evaluated the risk factors for obstructive sleep apnea in snoring patients, and also analyzed the risk factors that could predict the severity of obstructive sleep apnea. **Methods:** The inclusion criteria were patients 1) who visited our hospital with a chief complaint of snoring as witnessed by a sleep partner and 2) who underwent overnight polysomnography. The primary endpoint was the presence of obstructive sleep apnea as a dependent variable. **Results:** One hundred forty-seven patients met the inclusion criteria. Of the 147 patients, 109 patients were diagnosed with obstructive sleep apnea. Multivariate analysis showed that old age and large neck circumference were significant independent variables for predicting the presence of obstructive sleep apnea, whereas hypertension and large neck circumference were independent variables for predicting the severity of obstructive sleep apnea. **Conclusions:** We demonstrated that neck circumference can be used to predict the presence as well as the severity of obstructive sleep apnea in snoring Asian patients. **J Sleep Med 2015;12(2):34-38**

Key Words: Neck, Risk factors, Sleep apnea, Polysomnography.

Introduction

Obstructive sleep apnea (OSA) is a common sleep disorder characterized by repetitive episodes of apnea and hypopnea during sleep.[1] The symptoms include excessive daytime sleepiness, non-refreshing sleep, daytime fatigue, and decreased concentration, which may cause marked impairment in social or occupational functioning.[2] In addition, the patients with OSA were shown to have an increased risk of cardiovascular disease, stroke, hypertension, diabetes mellitus, depression, and impaired cognitive function.[1,3,4] Therefore, an early diagnosis and treatment of OSA are important. The gold standard for the diagnosis of OSA is overnight polysomnography.[1] However, because polysomnography is expensive and has limited availability with complex technical support, it is essential to know the predictive risk factors for OSA. Based on these predictive risk factors, it is possible to determine which patients should have priority for undergoing polysomnography.

Documented risk factors for OSA include advanced age, male gender, hypertension, large neck circumference, and obesity. These risk factors are used in the snoring, tiredness, observed apnea, high blood pressure, body mass index (BMI), age, neck circumference, gender questionnaire, which is a scoring model to screen for OSA.[5] Of these factors, large neck circumference is one of the most important risk factors for OSA. Previous studies demonstrated that large neck circumference was a risk factor for severe OSA and the most important predictor of OSA.[6-8] However, some controversy remains, because other studies demonstrated that large neck circumference was not associated with OSA.[2,9,10] In addition, neck circumference and BMI are highly correlated, and BMI has been the most widely used parameter to describe obesity.[6] One study reported that a 10% weight gain predicted an approximate 32% increase in the apnea-hypopnea index (AHI), and a 10% weight loss predicted a 26% decrease in the AHI.[11] This brings up the question whether large neck circumference is an independent risk factor for OSA. Moreover, many studies have been performed in Caucasians, but few studies have investigated the relationship between neck circumference and OSA in Far East Asians.[2,6,8-10,12-17] Asians are different from

Caucasians with respect to OSA in many ways. Asians are known to have a greater severity of OSA compared to Caucasians, when matched for BMI.[18,19] In addition, Asians are generally less obese than Caucasians, and pathogenesis of OSA could be different according to obesity. Upper airway soft tissue enlargement may play a more important role in the pathogenesis of OSA in obese patients, whereas cephalometric abnormalities of bony structure may be the predominant risk factors in non-obese patients.[20] Hence, a study in Asian patients is needed.

In the present study, we evaluated several clinical factors including neck circumference and BMI in Asian patients with OSA compared to individuals with simple snoring using the scoring manual prepared in 2007. In addition, we analyzed the clinical factors that could predict the severity of OSA.

Methods

This study was conducted with an approval from the Institutional Review Board at our hospital. This case-control observational study was performed retrospectively at a single tertiary hospital. From our hospital database, we reviewed the medical records of our patients from December 2010 to November 2013. The inclusion criteria were patients 1) who visited our hospital with a chief complaint of snoring as witnessed by a sleep partner and 2) who underwent overnight polysomnography at our hospital. The exclusion criteria were patients 1) younger than 14 years of age, 2) with a history of severe lung disease, congestive heart failure or neuromuscular disease, 3) who had previously received or have been receiving treatment for OSA such as continuous positive airway pressure or tonsillectomy, or 4) with central sleep apnea.

An overnight polysomnography was performed on all of the patients in the sleep laboratory at the institution. Electroencephalography, electrooculography, electrocardiography, chin and tibial electromyography, oral-nasal airflow meter measured by thermocouples and nasal pressure, oxyhemoglobin saturation measured by finger pulse oximeter, chest and abdominal movements measured by respiratory inductive plethysmography, body position, and snoring noise captured by a microphone, were recorded. Digital video recording was performed throughout the night. The polysomnographic recordings were analyzed by a certified polysomnographic technologist. Apnea was defined as cessation of airflow for more than 10 seconds, and hypopnea was defined as a ≥50% decrease in airflow that persisted for more than 10 seconds, and was accompanied by oxygen desaturation of 3% or greater or by arousal.[21] AHI was calculated as the total number of respiratory events (apnea plus hypopnea) per hour of sleep. Height, weight, and neck circumference were determined on the night of sleep study. Height, in centimeters, was measured with a stadiometer. Weight, in kilograms, was measured with a scale. BMI was calculated as the weight in kilograms divided by the square of the height in meters (kg/m^2). Neck circumference, in centimeters, was measured at the level of cricothyroid membrane with a tape measure.

The diagnosis of OSA was made based on AHI >5 with witnessed snoring or apnea,[22,23] which was used to divide the patients into two groups according to the presence and absence of apnea. In addition, we categorized the severity of sleep apnea based on the AHI into three groups: mild (AHI >5 to ≤15), moderate (AHI >15 to ≤30), and severe (AHI >30).

The primary endpoint for this study was the presence of OSA as a dependent variable. The differences were analyzed using clinical variables such as sex, age, hypertension, BMI, and neck circumference as independent variables. Comparisons were performed using chi-square test for categorical variables, and Student's t-test or Mann-Whitney U-test for numerical variables. We also quantified correlations between AHI and age, BMI, and neck circumference using Spearman's rank correlation test. We performed multiple logistic regression analyses of clinical variables such as sex, age, hypertension, BMI, and neck circumference to determine the odds ratio for predicting the presence of OSA. In addition, we performed multiple linear regression analysis of the clinical variables affecting AHI of the patients with OSA, and created a prediction model. We also analyzed the difference in age, BMI, and neck circumference according to the severity of OSA using one-way analysis of variance or Kruskal-Wallis test. All statistical tests were performed using MedCalc® (MedCalc Software version 13, Ostend, Belgium). For all calculations, a *p*-value of less than 0.05 was considered statistically significant. Categorical variables were presented as frequency and percentage. Numerical variables that had a normal distribution were presented as mean±standard deviation, and those that did not have a normal distribution were presented as median with 95% confidence interval (CI) and range.

Results

One hundred forty-seven patients met the inclusion and exclusion criteria. One hundred eighteen patients were men, and 29 patients were women. The mean patient age was 45.0±14.4 years. Thirty-nine patients (26.5%) had hypertension. The median BMI was 25.4 kg/m^2 (95% CI 24.6–26.4 kg/m^2, range 17.6–36.4 kg/m^2). The mean neck circumference was 37.9±3.4 cm. Polysomnography revealed a median AHI of 22.2 (95% CI 15.4–30.2, range 0–111.8). One hundred nine of the 147 patients were diagnosed with OSA. Of the 109 patients, 23 patients had mild OSA, 23 patients had moderate OSA, and 63 patients had severe OSA.

Table 1 shows the comparison of clinical variables between patients with and without OSA. Patients with OSA comprised more number of men, were older, had higher BMI and larger neck circumference compared to those without OSA. In addition, a positive correlation between AHI and age, BMI, and neck circumference was identified (age, r=0.209, p=0.0111; BMI, r=0.281, p=0.0006; neck circumference, r=0.416, p<0.0001, by Spearman's rank correlation test). After adjusting for variables, multiple logistic regression analysis showed that old age and large neck circumference were significant independent variables for predicting the presence of OSA (Table 2).

When we limited the analysis to the patients with OSA, multiple linear regression analysis showed that presence of hypertension and large neck circumference were independent variables for predicting the severity of OSA (p=0.0157, 0.0329, respectively). The equation of the linear regression model is shown below, and this model explained approximately 12% of the variation in the AHI.

AHI=-54.7316+(neck circumference×2.9484)+(hypertension×13.8654)

There was no difference in the age and BMI between mild, moderate, and severe OSA patients, but there was a significant difference in the neck circumference among the three groups according to the severity of OSA (Table 3).

Discussion

The major finding of this study was that old age and large neck circumference were risk factors for presence of OSA, whereas presence of hypertension and large neck circumference were associated with severity of OSA. Neck circumference was the only factor that predicted the presence as well as the severity of OSA in snoring Asian patients. In addition, we found that there was strongest positive correlation between AHI and neck circumference (r=0.416), and neck circumference was more associated with OSA than BMI and age. We also found that there was a significant difference in the neck circumference between mild, moderate, and severe OSA patients. The strength of this study was that the study population included only Far East Asian subjects, and we

Table 1. The difference of clinical variables between snoring patients with and without OSA

Parameter	With OSA (n=109)	Without OSA (n=38)	p-value
Men, n (%)*	94.0 (86.2)	24.0 (63.2)	0.0045
Age, years (±SD)†	47.4 (±12.5)	38.2 (±17.3)	0.0006
Hypertension, n (%)*	32.0 (29.4)	7.0 (18.4)	0.2706
BMI, kg/m^2 (range)‡	26.0 (17.6–36.4)	24.2 (17.7–32.2)	0.0204
Neck circumference, cm (±SD)†	38.7 (±3.0)	35.6 (±3.3)	<0.0001

*Chi-square test, †Student's t-test, ‡Mann-Whitney U-test. OSA: obstructive sleep apnea, BMI: body mass index, SD: standard deviation

Table 2. Multiple logistic regression analysis of clinical variables in snoring patients with and without obstructive sleep apnea

Independent variable	Adjusted odds ratio	95% confidence interval	p-value
Men	1.38	0.28–6.78	0.6869
Age	1.06	1.02–1.10	0.0036
Hypertension	1.74	0.53–5.66	0.3605
BMI	1.01	0.84–1.21	0.9173
Neck circumference	1.44	1.01–1.89	0.0085

BMI: body mass index

Table 3. The differences of age, BMI, neck circumference among mild, moderate, and severe OSA patients

Parameter	(1) Without OSA (n=38)	(2) Mild OSA (n=23)	(3) Moderate OSA (n=23)	(4) Severe OSA (n=63)	p<0.05
Age, mean*	38.6	46.7	46.5	47.8	(1) vs. (3), (4)
BMI, mean†	24.2	25.1	25.7	26.8	(1) vs. (4)
Neck circumference, mean*	35.4	37.5	38.1	39.3	(1) vs. (2), (3), (4) (2) vs. (1), (3), (4) (3) vs. (1), (2), (4) (4) vs. (1), (2), (3)

*One-way analysis of variance test, †Kruskal-Wallis test. OSA: obstructive sleep apnea, BMI: body mass index created a prediction model for OSA. In addition, we used a relatively updated scoring system for AHI.

Obesity is a major risk factor for OSA.[10] Soft tissue enlargement around the upper airway caused by obesity related subcutaneous and periluminal fat deposits may alter the compliance of upper airway walls and narrow the luminal area. Thus, this increased likelihood of airway collapse may explain the pathogenesis of OSA in obese patients.[20,24] In addition, the pathogenesis of OSA may be mediated by secondary effects induced by obesity, such as inflammation, insulin resistance, visceral adiposity, and central neural mechanisms.[25] Obesity also negatively affects lung function, which may exaggerate an existing airway disease, and obese subjects also have increased respiratory resistance and reduced lung volumes.[26] However, a previous epidemiologic study found that 60% of patients with OSA were not obese.[27] In addition, most of the Far East Asian men with OSA were not obese.[18] In this study, we found that large neck circumference was more associated with OSA than obesity, and this result was consistent with a previous study in Japanese subjects.[8] A plausible explanation for this finding is that localized adipose tissue distribution around the neck could be more associated with OSA than general obesity, and OSA may be more vulnerable to the change in neck circumference of Asian patients.[28] Asians have shorter and steeper anterior cranial bases with smaller and more posteriorly positioned mandibles compared to Caucasians,[29] and they have craniofacial characteristics which render the upper airways more prone to collapse.[18,19] Thus, neck circumference may be a more effective factor in determining the presence and severity of OSA in Asian patients. In addition, neck circumference is considered a marker of central obesity and has been associated not only with OSA but also with increased cardiovascular risk and insulin levels.[30] Because neck circumference is an easily obtainable measure with the use of only a tape measure, it is a useful measure in clinical practice.

Age is a well-known risk factor for OSA. A previous study demonstrated that age was an independent risk factor for OSA, even if weight and neck circumference increased with age.[31] Decrease in the muscle tone with aging and consequent reduction in the dimensions of upper airway lumen may be a pathogenic mechanism for OSA.[31] In the present study also, we confirmed that old age was a risk factor for the presence of OSA. Previous studies also revealed that hypertension was found in 45% of patients with OSA.[32] In this study also, we found that more number of patients with OSA have hypertension compared to the number of patients without OSA (29% vs. 18%), although there was no statistical significance. In addition, our results revealed that hypertension was a significant variable that could predict the severity of OSA among patients with OSA.

Despite our successful demonstration of the association between neck circumference and OSA independent of obesity, there were several limitations to this study. First of all, this was a cross-sectional retrospective study. Thus, we could not determine the actual effect of neck circumference on the development and severity of OSA. Second, because we enrolled only those patients who visited the sleep disorder clinic, the sample did not reflect the features of the general population. Thus, it is not possible to extrapolate our findings to the general population. Third, we did not perform anatomic evaluation of factors such as enlarged tonsils, oropharyngeal crowding, elongated uvula, redundant uvula, and soft palate, which might influence the incidence of OSA.[33] Thus, we could not determine the effects of anatomic factors. Lastly, our linear regression model for predicting AHI could explain only 12% of the variation. The non-use of upper airway anatomical findings might have decreased the efficiency of our models.

In conclusion, we demonstrated that neck circumference could be used to predict the presence as well as severity of OSA in snoring Asian patients. Because neck circumference is an easily obtainable measure with the use of only a tape measure, it is a useful marker in clinical practice to assess the need for polysomnography.

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