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ORIGINAL RESEARCH

Which oropharyngeal factors are significant risk factors for obstructive sleep apnea? An age-matched study and dentist perspectives

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Objective: Obstructive sleep apnea (OSA) is a common sleep breathing disorder. Untreated OSA may lead to a number of cardiovascular complications. Dentists may play an important role in OSA detection by conducting careful oral examinations. This study focused on the correlation of oral anatomical features in Thai patients who presented with OSA.

Methods: We conducted a prospective comparative study at a sleep/hypertension clinic and a dental clinic at Khon Kaen University in Thailand. Patients with OSA were enrolled in the study, along with age-matched patients with non-OSA (controls). Baseline characteristics, clinical data, and oropharyngeal data of all patients were compared between the two groups. Oropharyngeal measurements included tongue size, torus mandibularis, Mallampati classification, palatal space, and lateral pharyngeal wall area. Multivariate logistic regression analysis was used to identify the factors associated with OSA.

Results: During the study period, there were 156 patients who met the study criteria; 78 were patients with OSA and the other 78 were healthy control subjects. In the OSA group, there were 43 males with a mean age of 53 (standard deviation 12.29) years and a mean BMI of 30.86 kg/mm^2. There were 37 males in the control group with a mean age of 50 (standard deviation 12.04) years and a mean BMI of 24.03 kg/mm^2. According to multivariate logistic analysis, three factors were perfectly associated with OSA, including torus mandibularis class 6, narrow lateral pharyngeal wall, and Mallampati class 4. There were two other significant factors associated with having OSA, namely, BMI and Mallampati classification. The adjusted odds ratios (95% confidence interval) of these two factors were 1.445 (1.017, 2.052) and 5.040 (1.655, 15.358), respectively.

Conclusion: Dentists may play an important role in the detection of OSA in patients with high BMI through careful oropharyngeal examination in routine dental treatment. A large torus mandibularis, Mallampati class 4, and a narrow lateral pharyngeal wall are important anatomical risk factors for OSA.

Keywords: obstructive sleep apnea, neck circumference, torus mandibularis, tongue size, Mallampati classification, palatal vault, lateral pharyngeal wall, hypertension

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Introduction

The prevalence of obstructive sleep apnea (OSA) has been reported to be 2%–4% in the general population.[1] It is a contributing factor for cardiovascular diseases such as hypertension, coronary artery disease, and stroke, as well as for traffic accidents and poor quality of life.[2–4] Diagnosis of OSA can be made using polysomnography in patients who have an apnea–hypopnea index of more than five events per hour. Obesity is a major risk factor for OSA. Other risk factors are oral abnormalities such as macroglossia and a narrow pharynx.[5] Early detection and treatment of OSA have been shown to reduce the risk of

215

cardiovascular diseases and, thus, death from heart diseases, and to reduce the frequency of strokes.[3]

Dentists actually play an important role in OSA diagnosis and treatment. They see patients' oral cavity in daily practice and can identify those who are at risk of OSA. In addition, oral appliances can be custom-made for OSA treatment. Several craniofacial factors have been reported to be important risk factors for OSA. Neck circumference of >17 inches (43.2 cm) in men and 16 inches (40.6 cm) in women increases the risk of OSA. Similarly, large tongue and Mallampati classification are also significant predictors of OSA. A small study from People's Republic of China conducted with 15 patients with OSA showed that neck circumference and craniofacial measurements such as anterior superior hyoid to mandibular plane or the velum tip to the pharyngeal wall parallel to the Frankfurt horizontal were associated with OSA.[6] These factors may require several landmarks and are not practical for clinical use. This study aimed to evaluate if any oropharyngeal parameters associated with OSA can be detected using methods that are more practical for a dentist.

Methods

This prospective study was a sleep/hypertension clinic, out patient unit, Department of Medicine, Faculty of Medicine and a dental clinic, out patient unit, Faculty of Dentistry, Khon Kaen University from August to October 2013. We compared the craniofacial factors of patients with OSA and patients with non-OSA. Patients diagnosed with OSA were consecutively enrolled at the sleep/hypertension clinic, while non-OSA controls were enrolled at the dental clinic.

The diagnosis of OSA was made based on the presence of apnea–hypopnea index greater than or equal to five events per hour. Age-matched controls were enrolled at the dental clinic after they were found to have a negative risk of OSA using the Berlin questionnaire.[7] The age of each control subject matched to each patient was between ±3 years. Patients were also excluded if they were younger than 30 years of age, had no functional teeth, or had previously undergone surgical procedures to treat OSA. The study protocol was approved by the Khon Kaen University Institutional Ethics Committee of human research (HE561022).

Baseline characteristics, clinical data, and oropharyngeal data of all patients were collected. Neck circumference was measured over cricoid cartilage in a neutral position. Oropharyngeal evaluation included torus mandibularis, tongue size, Mallampati classification, palatal space, and lateral pharyngeal wall area. Details of each measurement were as follows.

Torus mandibularis is the hard tissue located at the lower mandible. According to the classification of Agbaje et al[8] and Reichart et al,[9] there are six levels of torus mandibularis identified by the diameter and location of the tori as follows:

Level 1: diameter <6 mm on one side of lower mandible
Level 2: diameter <6 mm on both sides of lower mandible
Level 3: diameter of 6 mm to 2 cm on one side of lower mandible
Level 4: diameter of 6 mm to 2 cm on both sides of lower mandible
Level 5: diameter >2 cm on one side of lower mandible
Level 6: diameter >2 cm on both sides of lower mandible

Tongue size as identified by Huynh et al's classification by using tongue position and tongue scalloping was as follows[10]:

Small tongue: tongue edge does not cover lower teeth in resting position.
Normal tongue: tongue edge partially covers lingual cusps of lower teeth.
Macroglossia: tongue edge covers more than half of lower teeth or scalloped tongue is seen.

Participants were asked to protrude their tongues as much as possible in a neutral sitting position and classified according to Mallampati classification[11] as follows:

Class 1: soft palate and uvula completely visible
Class 2: soft palate and uvula partially visible
Class 3: soft palate and base of uvula visible
Class 4: only hard palate visible

Mallampati classification in each patient was assessed by one author (TL). TL and KS (a sleep medicine physician) were piloted 10 patients in Mallampati evaluation prior to the study. The kappa correlation score of both evaluators (TL and KS) was 0.9.

Palatal space was determined by palatal width and depth. The palatal width was measured by placing and folding a sterile hard paper between the inner gums of both upper first molars. This sterile hard paper was then measured with a ruler. The palatal width was classified according to Patel as narrow (<30 mm), normal (30–42 mm), and large palatal width (>42 mm).[12] The palatal depth was measured by placing a sterile toothpick in the center of the previous position of the sterile hard paper, and the palatal width was measured to the top of the hard palate. The palatal depth was classified into one of three levels: short or shallow palatal depth (<15 mm), normal (15–20 mm), and deep palatal depth (>20 mm).

The lateral pharyngeal wall area was defined as either normal or narrow by using a tongue blade to compress the patient's tongue. If no lateral soft tissue was found in the pharyngeal cavity, the lateral pharyngeal wall area was recorded as normal. If lateral soft tissue invaded the pharyngeal cavity, this was classified as narrow.[13]

Sample size calculation

A previous study showed that macroglossia had a prevalence of 41.2% and the odds ratio (OR) for OSA was 2.[13] According to this data, the estimated prevalence of macroglossia in non-OSA population was 26%. With confidence of 95% and a power of 80%, the estimated sample size was 78 in each group (OSA and non-OSA groups).

Statistical analyses

Baseline and clinical characteristics of both patients with OSA and controls were analyzed using descriptive statistics. Wilcoxon rank sum/Student's *t*-test and Fisher's exact tests/chi-square test were applied to compare the differences in numbers and proportions between the two groups, respectively, when appropriate. *P*-values <0.05 were considered significant.

Univariate logistic regression analysis was applied to calculate the crude OR of individual variables for OSA. All clinically significant variables were included in subsequent multivariate logistic regression analyses. Analytical results were presented as crude OR, adjusted OR, and 95% confidence intervals. The goodness of fit of the multivariate logistic regression model was tested using the Hosmer–Lemeshow method. All data analysis was performed using STATA software (StataCorp LP, College Station, TX, USA).

Results

One hundred and fifty-six patients met the study criteria; of these, 78 were in the OSA group and the other 78 were control subjects. The OSA group patients had a mean age of 53.33 years and a mean BMI of 30.86 kg/m^2; 43 of the patients were male. The control group subjects had a mean age of 50.40 years and a mean BMI of 24.03 kg/m^2; 37 subjects were male in this group.

The OSA group displayed five different anatomical factors that differed from the control group, including neck circumference, palatal width, macroglossia, Mallampati classification, and narrowness of the lateral pharyngeal wall (Table 1). The OSA group had significantly larger neck circumference (41.02 vs 36.38 cm) and a higher proportion of subjects with wide palatal width (80.27% vs 42.31%), macroglossia (66.67% vs 19.23%), Mallampati class 4 (50.00% vs 14.10%), and narrow lateral pharyngeal wall (31.75% vs 0%) than the control group.

According to multivariate logistic analysis, three factors were perfectly associated with OSA, including torus mandibularis class 6, narrow lateral pharyngeal wall, and Mallampati class 4. Two other factors that were also independently associated with OSA were BMI and Mallampati classification (Table 2).

Discussion

Dentists can detect patients with OSA through oral examination in daily practice. First, redness of the soft palate and uvula area may be an evidence of snoring.[14] If any of the following are present, OSA should be considered: torus mandibularis larger than 2 cm, narrow lateral pharyngeal wall, Mallampati class 4, or obesity. The first three factors

Table 1 Comparison of clinical factors between patients without and with OSA

Factors	Without OSA (n=78)	With OSA (n=78)	*P*-value
Age, years	50.40 (12.04)	53.33 (12.29)	0.103
Male sex	37 (44.44)	43 (55.13)	0.423
Weight, kg	63.08 (10.53)	82.46 (18.43)	<0.001
Height, m	1.62 (0.78)	1.63 (7.98)	0.237
BMI, kg/m^2	24.03 (2.91)	30.86 (6.53)	<0.001
Hypertension, n (%)	0	49 (68.06)	<0.001
Diabetes, n (%)	0	18 (25.00)	<0.001
Neck circumference, cm	36.38 (2.88)	41.02 (3.83)	<0.001
Palatal height: depth, n (%)	9 (11.54)	8 (10.26)	0.423
Palatal width: width, n (%)	33 (42.31)	15 (19.23)	0.003
Palatal width/height ratio	2.38 (2.24–2.96)	2.46 (2.12–2.78)	0.554
Large torus mandibularis, n (%)	1 (1.28)	5 (6.41)	0.360
Macroglossia, n (%)	15 (19.23)	52 (66.67)	<0.001
Mallampati class 4, n (%)	11 (14.10)	39 (50.00)	<0.001
Narrow lateral pharyngeal wall, n (%)	0	20 (31.75)	<0.001

Abbreviation: OSA, obstructive sleep apnea.

Table 2 Significant factors associated with having OSA according to multivariate logistic regression analysis

Factors	Crude OR	Adjusted OR
BMI	1.497 (1.300, 1.723)	1.445 (1.017, 2.052)
Mallampati classification	6.867 (3.956, 11.921)	5.040 (1.655, 15.358)

Notes: Data presented as OR (95% CI). The final model is adjusted for age, sex, neck circumference, palatal width/height ratio, torus mandibularis, and tongue size. Torus mandibularis class 6, narrow lateral pharyngeal wall, and Mallampati class 4 perfectly predicted OSA. The Hosmer-Lemeshow Chi-square test was 4.33 (*P* value 0.826).
Abbreviations: OSA, obstructive sleep apnea; OR, odds ratio; CI, confidence interval.

perfectly predicted OSA by multivariate logistic regression analysis, indicating a very high risk of OSA.

Obesity is the main risk factor for OSA.[14] In this study, we found that for each 1 kg/m^2 BMI increase, risk factors for OSA increased by 1.5 times. Neck circumference of >40 cm in Asian populations is associated with OSA and obesity,[15] but it was not an independent factor for OSA in this study. This may be explained by the greater effect of BMI compared to neck circumference.

Mallampati class 4 and narrow lateral pharyngeal wall,[13] indicating a narrow oropharyngeal airway, suggest high risk of OSA. Previous studies have also shown that a narrow oropharyngeal space increases the risk of OSA.[16–18] Tongue volume/oral cavity volume ratio was higher in patients with OSA compared with controls.[17] The risk of OSA in subjects with Mallampati class 3 is five times higher than that in those with Mallampati class 2 (Table 2). Even though macroglossia is another factor indicating a narrow oropharyngeal cavity, it is not an independent factor for OSA after adjustments are made for other factors such as age, sex, and BMI (Table 2). These data suggest that only some oropharyngeal factors, and not all of them, are important risk factors for OSA.

Torus mandibularis is an anatomical variation that may be a risk factor for OSA. The prevalence of these tori may be different among different countries or ethnicities. The prevalence rates of tori in Thai and German populations were 9% and 2.4%, respectively.[9] In this study, the overall prevalence of tori was 30.13% (47 subjects). Large tori mandibulares (level 6) were more common in patients with OSA than in control subjects (6.4% vs 1.3%). The proportion of subjects with large torus mandibularis was not statistically significant according to Fisher's exact test. However, it perfectly predicted OSA according to multivariate logistic regression analysis. The latter statistical method is more robust, more reliable, and controls other confounders. In other words, large torus mandibularis (>2 cm) indicated high risk of OSA.

OSA group had lesser proportion of patients with wide palatal width compared with control group, as shown in Table 1 (19.23% vs 42.31%). This indicates that narrow palatal width may be more common in patients with OSA, as previously reported.[12] However, after adjusting for other factors (Table 2), the palatal width/height ratio was not found to be an independent factor for OSA. Only Mallampati classification remained significant in the final model. We used the palatal ratio instead of either palatal width or palatal height in the model. The reason is that the palatal factor should be an area, not just only height or width. Also, using numeric values (palatal ratio) is more robust than categorical data (narrow or wide) when put in the statistical model.

The strength of this study was that both groups of patients were age matched, reducing confounding from age which is an important risk factor for OSA. There are several limitations in this study. Subjects were enrolled in the control group if they obtained a negative result on using the Berlin questionnaire. As a result, hypertension was one of the exclusion criteria and could not be included in the multivariate logistic analysis. Some oropharyngeal and physical factors were not included in this study, such as malocclusion or waist circumference.[19–22] This study may not apply to other specific populations (ie, children who may not have fully developed anatomical structure).[23–27] Further studies using a larger study population and looking at other risk factors such as malocclusion and torus palatinus are necessary to confirm our results.

Conclusion

Dentists may play an important role in the detection of OSA in hypertensive or high BMI patients through routine oropharyngeal examination. Large torus mandibularis, Mallampati class 4, and narrow lateral pharyngeal wall are important anatomical risk factors for OSA.

Acknowledgments

Disclosure

The authors report no conflicts of interest in this work.

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