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ORIGINAL ARTICLE

Snoring in a sitting position and neck circumference are predictors of sleep apnea in Chinese patients

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Abstract
Background Snoring is a common symptom among the adult population, and it is the most common complaint in patients with obstructive sleep apnea (OSA) syndrome. Patients who snore in a sitting position while taking a nap or sleeping may have a narrower upper airway. The aim of this study was to evaluate if snoring in a sitting position is a predictor of OSA in patients.
Method We prospectively enrolled 166 SS+ (with a history of snoring in a sitting position) subjects and 139 SS− (who denied having a history of snoring in a sitting position) patients. All of the participants received questionnaires as well as a standard polysomnography thereafter.
Result Patients with self-reported snoring in a sitting position (with a tilt position greater than 70°, SS+ group) had a higher body mass index as well as greater neck, waist, and buttock circumference and scored higher on the Epworth Sleepiness Scale. During the polysomnographic study, the SS+ group had a higher percentage of N1 sleep and lower percentage of N2 sleep. In addition, the SS+ group had a higher apnea–hypopnea index (AHI) as well as higher arousal index and oxygen desaturation index. The sensitivity and specificity of the SS+ group for OSA (defined as AHI≥5) were 0.59 and 0.73, respectively, with a positive predictive value of 0.93. The likelihood ratio was 2.2. On the other hand, the sensitivity and specificity of the SS+ group for moderate to severe OSA (defined as AHI≥15) were 0.82 and 0.48, respectively. Both SS+ and greater neck circumference have a high likelihood ratio for diagnosing OSA.
Conclusion In the present study, the symptoms of self-reported snoring in a sitting position and greater neck circumference can be useful clinical predictors of OSA in Chinese patients.

Keywords Respiratory inductive plethysmography · Obstructive sleep apnea syndrome

Introduction

Obstructive sleep apnea (OSA) syndrome is a disease characterized by recurrent upper airway collapse leading to repetitive episodes of hypoxemia and arousal during sleep [1]. In routine sleep clinics, physicians make their own judgments as to whether or not a patient needs polysomnographic study. Predictors such as snoring, daytime sleepiness (mostly using Epworth Sleepiness Scale (ESS)), and body mass index show a low sensitivity, specificity, and likelihood ratio for OSA. On the other hand, cephalometry is a good predictor for OSA, but it is not easily measured at our clinics [2].

Traditionally, patients go to a sleep center for study mostly due to snoring and daytime sleepiness. However, in the study of Hoffstein and Szalai [3], the positive predictive value for snoring was 49 %, witnessing sleep apnea was 56 %, and nocturnal choking was 44 %. Subjective impression had a sensitivity of 60 % and a specificity of 63 %. In the study of Netzer et al. [4], the Berlin questionnaire, a

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combination of ten questions regarding snoring, witnessing sleep apnea, body habitus, and associated disorders, has a good sensitivity (86 %) and likelihood ratio of 3.8 for obstructive sleep apnea, which defined a respiratory disturbance index (RDI) of ≥5/h.

In our daily clinical practice in Taiwan, we found that many patients with sleep apnea snored. However, many patients snored while they took naps on the bus and train and while utilizing other forms of public transportation. All of the seats in public transportation in Taiwan are at around 70°–90° angle in relation to their vertical line of seat. We found that many patients with a severe degree of OSA complained of snoring while in a sitting position. For this reason, we studied the sensitivity and specificity of snoring while in a sitting position as a predictor of severity of OSA.

Materials and methods

Study subject

In this prospective, case–control study, 305 Chinese adult subjects who came for outpatient service at our sleep center in Hualien Tzu-Chi General Hospital were enrolled for the study from 2010 to 2012. Snoring in a sitting position on public transport was a question asked routinely before polysomnographic study was performed. The answer of "yes" (SS+ group), "no," or "unknown" (both answering no or unknown were the SS− group) was checked again with the patient's relatives or friends. All subjects accepted the complete study of overnight polysomnography. Basic data and cephalometric measurements (neck circumference, waist circumference, and hip circumference) and ESS scores were obtained before polysomnography. Subjects under 20 years old were excluded. The study was approved by our institution's investigational review board. All of the enrolled subjects provided informed consent. There was no funding for the study.

Polysomnography

All patients underwent one night of polysomnographic study (Embla A10, Embla, Broomfield, CO, USA) at the sleep center in Hualien Tzu-Chi General Hospital. Electroencephalogram (C3 and C4), electro-oculogram, chin and leg electromyogram, and electrocardiography (modified V2 lead) were included in the polysomnographic study. Respiration was measured with a nasal pressure cannula (135 cm), and oxyhemoglobin saturation was measured with pulse oximetry. Data in the sleep stages were manually recorded by the international criteria developed by Rechtschaffen and Kales [7]. Acceptable studies with sufficient qualities were those which ranged within at least 6 h of sleep in which that sleep stage and respiratory event were detected. According to the parameters of the task force of the American Academy of Sleep Medicine [5], apnea was defined as a period of breathing cessation for at least 10 s, and hypopnea was defined as a 50 % reduction in breathing or of a reduction in breathing of less than 50 % associated with a 3 % desaturation of oxihemoglobin or arousal. Apnea–hypopnea index (AHI) was defined as the number of obstructive apneas plus hypopneas per hour of total sleep time. Subjects who came to the sleep center for sleep study took neither alcoholic nor caffeinated drinks 2 days before the study. Categories of OSA were defined according to the AHI (AHI<5, no OSA; 5≤AHI<15, mild OSA; 15≤AHI<30, moderate OSA; and AHI≥30, severe OSA).

Statistical analysis

Analysis was performed using SPSS version 10.0 statistical package for Windows (SPSS, Chicago, IL, USA). Independent samples t test was used to compare the two groups (SS+ and SS−). Two-sided p values of less than 0.05 were considered to indicate statistical significance.

Results

Among the 305 enrolled subjects, only 166 subjects knew that they snored while in a sitting position (SS+ group). Fifty-nine subjects knew they did not snore while in a sitting position, and 80 subjects could not verify if they snored while in a sitting position (SS− group), which was also confirmed by their relatives and friends. In the group with SS+ (Table 1), they were younger (age, 44.4±11.7 versus 47.9±14.1 years old) and had higher levels of body mass index (BMI, 29.7±5.6 versus 27.0±4.9 kg/m^2) as well as greater neck, waist, and hip circumference. The male gender was predominant in both groups (80 % versus 68 %). The SS+ group also scored higher on the ESS (10.2±4.5 versus 7.5±4.1). The N1 stage sleep and N2 stage sleep were significantly different between the SS+ and SS− groups. AHI (42.9±30.0 versus 25.4±25.9/h), arousal index (AI), and oxygen desaturation index (ODI) were also higher in the SS+ group (p<0.001).

The sensitivity, specificity, positive predictive value (PPV), and likelihood ratio (LR) of SS+ to diagnosed subjects with OSA (by a polysomnographic study of AHI≥5/h) were 58.9 %, 73.2 %, 93.4 %, and 2.20, respectively (Table 2). For subjects found to need treatment for OSA (usually by a polysomnographic study of AHI≥15), the sensitivity, specificity, PPV, and LR were

Table 1 Demographic data

Characteristic	SS+ group	SS− group	*p* value
N	166	139	
Age (years)	44.4±11.7	47.9±14.1	0.019
Gender, male (%)	80.1	68.1	
BMI (kg/m^2)	29.7±5.6	27.0±4.9	<0.001
ESS	10.2±4.5	7.5±4.1	<0.001
NC (cm)	39.5±3.6	37.2±3.9	<0.001
WC (cm)	100.4±15.6	93.3±13.1	<0.001
HC (cm)	103.0±15.4	96.5±12.1	<0.001
TST (min)	367.2±69.4	358.7±75.2	0.309
Sleep efficacy (%)	85.8±11.5	83.0±13.9	0.061
N1 (%)	29.8±19.8	23.8±16.6	0.004
N2 (%)	42.8±23.7	48.6±14.0	0.008
SWS (%)	9.3±8.6	9.2±9.2	0.908
REM sleep (%)	19.9±7.8	18.3±7.3	0.078
AHI (h^{-1})	42.9±30.0	25.4±25.9	<0.001
AI (h^{-1})	27.2±20.0	17.9±12.3	<0.001
ODI (h^{-1})	31.0±25.8	16.6±21.5	<0.001
OSA (%) (AHI≥5/h)	93.4	78.3	
Moderate to severe OSA (%) (AHI≥15/h)	78.3	54.3	

Data are shown as mean ± SD

SS+ subjects with self-reported snoring in a sitting position (with a tilt position greater than 45°), *SS−* subjects without self-reported snoring in a sitting position, *BMI* body mass index, *ESS* Epworth score, *NC* neck circumference, *WC* waist circumference, *HC* hip circumference, *TST* total sleep time, *SWS* slow wave sleep, *REM* rapid eye movement, *AHI* apnea–hypopnea index, *AI* arousal index, *ODI* oxygen desaturation index, *cm* centimeter, *min* minutes, *h* hours

63.4 %, 63.6 %, 73.2 %, and 1.74, respectively. The sensitivity, specificity, PPV, and LR of symptoms of snoring were 97.7 %, 9.8 %, 87.4 %, and 1.08, respectively. We also compared daytime sleepiness (ESS≥10) as a predictor in our study; the sensitivity, specificity, PPV, and LR were 44.5 %, 68.3 %, 90 %, and 1.40, respectively. In our previous study comparing the cephalometric study of Chinese OSA patients [2], the neck circumference (NC) of OSA patients was 39.8 cm, while that of non-OSA patients was 35.7 cm. Comparing the group in the present study, the non-OSA group and OSA group had a NC of 35.4±3.5 cm versus 39.2±3.6 cm; therefore, a NC>40 cm might be another good predictor to detect OSA in patients. The sensitivity, specificity, PPV, and LR of NC≥40 cm were 48.6 %, 87.8 %, 96.2 %, and 3.98, respectively. For those with both subjective complaint of SS+ and objective data of neck circumference greater than 40 cm, the sensitivity, specificity, PPV, and LR were 33.1 %, 95 %, 97.8 %, and 6.62, respectively.

Table 2 Diagnostic efficacy to identify OSA (defined by AHI≥5) from symptoms of self-reported snoring of sitting position (SS+), ESS, and NC (≥40 cm) and combined criteria of both SS+ and NC compared with standard polysomnography

	Sensitivity	Specificity	PPV	LR for SS+
SS+, for OSA	58.9	73.2	93.4	2.20
SS+, moderate to severe OSA (AHI≥15/h)	63.4	63.6	78.3	1.74
Snorer for OSA	97.7	9.8	87.4	1.08
ESS≥10 for OSA	44.5	68.3	90	1.40
NC (≥40 cm) for OSA	48.6	87.8	96.2	3.98
SS+ and NC (≥40 cm) for OSA	33.1	95	97.8	6.62

Data are presented in percentage

PPV positive predictive value, *NPV* negative predictive value, *OSA* obstructive sleep apnea syndrome, *AHI* apnea–hypopnea index

Discussion

In our present study, we presented one novel and important predictor of snoring while in a sitting position to detect OSA in Chinese patients. Snoring is the most common complaint in our clinics. The sensitivity, specificity, PPV, and LR were 58.9 %, 73.2 %, 93.4 %, and 2.20, respectively. As compared to the ESS, NC, and Berlin questionnaire as a predictor, snoring while in a sitting position is an easy question and quite a confident predictor to screen Chinese patients with OSA in busy daily clinics. Neck circumference also had a high likelihood ratio for diagnosing OSA. Combining, subjectively, snoring while in a sitting position and, objectively, neck circumference can correctly diagnose OSA.

In the study of Deegan and McNicholas [6], the positive PPV of observed apnea, snoring, being awaked from heartburn, and falling asleep while driving was 64 %, 63 %, 71 % and 70 %, respectively. They concluded that history and physical examination can predict OSA in only about 50 % of cases examined. In the study of Caffo et al. [7] from the Sleep Heart Health Study, NC, BMI, age, snoring frequency, WC, and snoring loudness had the largest impact on prediction performance, which might imply that body soft tissue deposition and cephalometric factor are important factors in OSA patients. On the other hand, numerous questionnaires or scores can be used to predict OSA in patients. The Epworth Sleepiness Scale is a good scale to identify patients with daytime sleepiness. However, the ESS was not a good predictor of OSA in our study (sensitivity 44.5 % and specificity 68.3 %) and in some other studies [8] (sensitivity and specificity of ESS≥10: 66 % and 48 %). The Berlin questionnaire [4] is a combination of items regarding snoring, witnessing apnea, body habitus, and associated disease such as hypertension, which has good sensitivity (86 %) and PPV (89 %). In another complex questionnaire such as the BASH'IM [9] (BMI≥45, age, witness of apnea, $HbA_{1C}\geq$ 6 %, fasting plasma insulin≥28 μm/L, and male sex), the score≥3 had good sensitivity (89 %) and specificity(81 %) in obese OSA patients (defined as AHI≥15/h).

Snoring is a sound produced by the vibrating structure of the upper airway. In the endoscopic observation during sleep [10–12], any membranous parts of the upper airway that lack cartilaginous support might vibrate. Snoring is a common complaint with a prevalence of approximately 40 % [13] and was one of the complaints for OSA in clinics in our present study. However, the PPV for snoring in OSA was only 49 % [3] and had a poor likelihood ratio in our present study.

Cephalometric study is widely studied in different ethnicities [2, 14, 15] and has a variety of different measurements. In Chinese OSA patients [2], the narrower bony structure and wider soft tissue like the tongue or soft palate on the oropharynx predicted a more severe AHI. In this study, neck circumference was positively correlated with the bony structure with distance from the gnathion to the gonion and strongly correlated with the area of the soft palate on the lateral cephalometric study. Combining the concept of snoring and cephalometric study, we hypothesized that the snorer who is sitting has a narrower bony and wider soft tissue with regard to the oropharynx. This hypothesis is supported in that the SS+ group had a greater neck circumference than the SS− group as shown in Table 1. If we combine snoring in a sitting position and neck circumference greater than 40 cm, the likelihood ratio of OSA can be as high as 6.62. Further study of direct cephalometric measurements on the bony structure and soft tissue in the SS+ versus SS− groups should be performed in order to prove this hypothesis.

Our study has a number of limitations that are worth noting. It was from one hospital-based center study with Chinese OSA patients. Direct cephalometric study was not performed in our study. Further studies of other ethnicities and epidemiology should be conducted.

In conclusion, we reported a novel and important clinical finding that snoring in a sitting position is an indicator of OSA in Chinese patients. The sensitivity, specificity, positive predictive value, and likelihood ratio of snoring in a sitting position and greater neck circumference for diagnosing OSA patients are acceptable. Both snoring in a sitting position and greater neck circumference should be considered as important predictors of OSA for Chinese patients in clinics.

Conflicts of interest None of the authors have conflicts of interest to declare.

References

1. Young T, Palta M, Dempsey J, Skatrud J, Weber S, Badr S (1993) The occurrence of sleep-disordered breathing among middle-aged adults. N Engl J Med 29:1230–1235
2. Chang ET, Shiao GM (2008) Craniofacial abnormalities in Chinese patients with obstructive and positional sleep apnea. Sleep Med 9:403–410
3. Hoffstein V, Szalai JP (1993) Predictive value of clinical features in diagnosing obstructive sleep apnea. Sleep 16:118–122
4. Netzer NC, Stoohs RA, Netzer CM, Clark K, Storhl KP (1999) Using the Berlin questionnaire to identified patients at risk of sleep apnea syndrome. Ann Int Med 13:485–491
5. Iber C, Ancoli-Israel S, Chesson A, Quan SF (2007) The AASM manual for the scoring of sleep and associated events. American Academy of Sleep Medicine, Westchester
6. Deegan PC, McNicholas WT (1996) Predictive value of clinical features for the obstructive sleep apnoea syndrome. Eur Respir J 9:117–124
7. Caffo B, Diener-West M, Punjabi NM, Samet J (2010) A novel approach to prediction of mild obstructive sleep disordered breathing in a population-based sample: the Sleep Heart Health Study. Sleep 33:1641–1648
8. Rosenthal LD, Dolan DC (2008) The Epworth Sleepiness Scale in identification of obstructive sleep apnea. J Nerv Ment Dis 196:429–431
9. Dixon JB, Schacheter LM, O'Brien PE (2003) Predicting sleep apnea and excessive day sleepiness in the severely obese. Chest 123:1134–1141
10. Gavrily N, Jensen O (1993) Theory and measurement of snorers. J Appl Physiol 74:2828–2837
11. Aittokallio T, Gyllenberg M, Polo O (2001) A model of snorer's upper airway. Math Biosci 170:79–90
12. Huang L, Williams JE (1999) Neuromechanical interaction in human snoring and upper airway obstruction. J Appl Physiol 86:1759–1763
13. Lugaresi E, Cirignotta F, Piana G (1980) Some epidemiological data on snoring and cardiocirculatory disturbances. Sleep 3:221–224
14. Dempsey JA, Skatrud JB, Jacques AJ, Ewanowski SJ, Woodson BT, Hanson PR, Goodman B (2002) Anatomic determinants of sleep-disordered breathing across the spectrum of clinical and nonclinical male subjects. Chest 122:840–851
15. Liu Y, Lowe AA, Zeng X, Fu M, Fleetham JA (2000) Cephalometric comparisons between Chinese and Caucasian patients with obstructive sleep apnea. Am J Orthod Dentofac Orthop 117:479–485