original article

Predictors of obstructive sleep apnea in snorers

Abdulsalam Saif Ibrahim, Ahmed Ali Almohammed, Mona Hassan Allangawi, Hisaham A.Aleem A.Sattar, Hassan Said Mobayed, Balamurugan Panneerselvam, Mary V. Philipose

From the Pulmonary Section, Department of Medicine, Hamad Medical Corportation, Doha, Qatar

Correspondence and reprint requests: Abdulsalam Saif Ibrahim, MD · Pulmonary Section · Department of Medicine · Hamad Medical Corportation · P.O. Box 3050 · Doha · Qatar · F: +974-439-2273 · salam145@yahoo.com · Accepted for publication August 2007

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BACKGROUND: Snoring is a common problem that poses a high risk for obstructive sleep apnea (OSA). We studied the contribution of risk factors for OSA in snorers referred for full-night polysomnography (PSG).

METHODS: A questionnaire was administered to subjects referred for PSG in the period from April 2002 to March 2005.

RESULTS: There were 191 (84%) snorers identified by 227 PSG studies. They had a mean age of 48.1±9.8 years, (age range, 23-73 years) and 78.5% were males. OSA as indicated by a respiratory disturbance index (RDI) of >5 events/hour was seen in 126 (66%) subjects. In males, 72.7% had OSA, with a mean RDI of 43.0±26 events/hour, versus 39% with OSA in females with a mean RDI of 27.8±26.5 events/hour ($P<0.001$). The OSA group had a higher mean Epworth Sleepiness Scale (ESS) ($P<0.001$), a larger mean neck circumference ($P<0.01$), an increased mean age ($P<0.05$), and more witnessed apneas ($P<0.001$) but not choking ($P=0.096$). The mean increase in body mass index was linked to OSA only in females ($P<0.05$) but not in the overall study ($P=0.507$). Multivariate analysis showed that ESS, male gender, and a history of witnessed apnea were associated with OSA, while controlling for obesity, large neck circumference, age, and history of choking.

CONCLUSION: In screening snorers for PSG, male gender, ESS and a history of witnessed apneas were the most important predictors of OSA, but other factors should be considered in referring snorers for PSG. In males, obesity did not contribute to the risk of OSA in our study population.

Snoring is an important health issue that is reported to occur in 20% to 60% of the adult population.[1] It is the most common symptom of OSA, a condition associated with disturbed sleep and excessive daytime sleepiness that is seen in at least 4% of men and 2% of women 30 to 60 years of age.[2] By itself, however, snoring does not definitely imply the presence of OSA.[3] A quick and reliable screening test would enable clinicians to detect the possibility of OSA during initial office visits and then decide which patients are at high risk and urgently in need of polysomnography (PSG). The Epworth sleepiness score (ESS) has been extensively used as an important parameter in predicting OSA and screening subjects before referral for PSG. Other factors considered are male gender, older age (>50 years),[4] body mass index (≥30),[5] neck circumference (≥17 inches in males and ≥16 inches in females),[6] history of apnea witnessed by the bedroom partner, and awakening with choking.[8] In this cross-sectional observational prospective study we estimated the frequency of OSA in snorers in our center and present our experience in assessing the factors associated with the polysomnographic diagnosis of OSA in this group.

PATIENTS AND METHODS

A pre-designed database with the demographic data, clinical details, symptom-specific questions for diagnosis of OSA. A questionnaire with ESS was administered to all patients presenting to the snoring clinic at Hamad General Hospital, a tertiary hospital in the state of Qatar.

A total of 227 adult subjects underwent PSG from April 2002 to March 2005 for different indications excluding pediatric cases. In this study, we recruited only adult subjects who were referred with a main complaint of snoring to rule out OSA. A total of 191 (84%) PSG studies met the following inclusion criteria: 1) age >18 years old; 2) snoring that was reported as frequent on most days of the week; 3) no previous sleep study done; 4) demographic data and Epworth sleepiness score

completed; 5) upper airway obstruction excluded by ENT specialist; 6) a full night PSG study with a total sleep time >6 hours. Narcoleptic patients, significant periodic limb movement index, predominantly central sleep apnea, and multiple sleep latency studies were excluded from the analysis.

A sleep study questionnaire that includes ESS was completed in the clinic and rechecked with the patient on the night of the sleep study. Sleepiness was defined as the score on the ESS, a well-validated eight item questionnaire that asks the subject to rate his or her likelihood of falling asleep in a variety of commonly encountered situations. Possible total score range from 0 (no sleepiness) to 24 (the most sleepy). A score of 11 or higher was considered to represent an abnormal degree of daytime sleepiness.[9] For apneas and choking, either subjects or bedroom partners were asked about episodes in which the patient stops breathing indicating apnea and then gives a loud gasp or snort when aroused by the apnea to describe the choking sensation.

Patients had an overnight PSG using the Alice 4 Resporonics system. The PSG consisted of 14 channel continuous polygraphic recording from surface leads for 2 electroencephalography, 2 electro-oculography, chin electromyography, electrocardiography, sensors for nasal airflow (thermister), tracheal sounds (microphone), thoracic and abdominal respiratory effort (piezo-electric), finger pulse oximeter, leg movements, body position and light. A trained physician scored sleep stages in 30-second epochs according to standard criteria. An apnea was defined as complete airflow cessation of more than 10 seconds. A hypopnea was defined as a reduction in airflow of >50% for more than 10 seconds that led to a 4% or greater oxyhemoglobin desaturation. Patients were grouped by their total respiratory disturbance index (RDI) score at PSG. These groups were RDI of 0 to 4.9 considered as normal, and those with RDI ≥5 considered abnormal and having OSA. The abnormal RDI group were subdivided to: RDI 5 to 14.9 (mild OSA), 15 to 29.9 (moderate OSA), and >30 (severe OSA).

The data are presented as means±SD for continuous variables and as percentages for categorical variables. Comparison between the groups was done with the t test for continuous variables and chi-square test for discrete variables. ANOVA test was used to study the average increase in ESS, BMI, NC and age in the different OSA severity. Multivariate logistic regression models were applied to identify the overall and independent factors in relation to OSA. The factors considered were sex, age ≥50 years old, ESS ≥11, and BMI ≥30 and a cut point for NC ≥ was chosen at 43 cm, history of witnessed apneas and awakening with choking. A P value of <0.05 was considered as statistically significant. All analysis was done with SPSS (Chicago, IL) version 10.0 for Windows.

RESULTS

A total of 227 PSGs were performed in the period between April 2002 to March 2005 for adult patients. Snorers comprised 191 (84%) subjects, including 150 men (78.5%) and 41 women (21.5%) who met the inclusion criteria and formed the basis for this analysis. The mean age was 48.1±9.8 years (age range, 23-73 years). Qatari subjects constituted 75 participants (39.3%) while other nationalities formed 116 participants (60.7%). The average sleep time was 6.33±0.20 hours. The characteristics of the two groups of normal RDI and abnormal RDI in relation to gender, age, neck circumference, BMI and ESS are shown in Table 1. Table 2 shows the significance of the relationship of age, NC, BMI, ESS for different categories of RDI.

OSA as indicated by an RDI ≥5 was seen in 126 of 191 (66%), with a mean RDI of 40.9±26.5 events/hour (Table 1). OSA was seen more in men than women (P<0.001). OSA was seen more in non-Qatari subjects (84 of 116, 72.4%) versus [38 out of 75 (52%)] in Qatari subjects (P< 0.05). Arousal index was higher in the OSA group versus the normal group (P<0.001).

Subjects were divided into four groups based on RDI: 65 (34%) subjects were considered normal (RDI <5), 30 (16.9%) subjects had mild OSA (RDI 5 to 14.9), 24 (12.5%) subjects had moderate OSA (RDI 15 to 29.9), and 72 (37.5%) subjects had severe OSA (RDI >30). The OSA group had a higher mean age of 49.1±9.4 years compared to 46.2±10.2 years in the normal group (P<0.05). Females had a non-significantly higher mean age of 51.8±8.2 years compared to 48.7±9.4 years in males (P=0.195). There were no statistically significant differences in the mean age comparing the different OSA categories.

The OSA group had a significantly higher mean NC compared to the normal group (P<0.05). In the OSA group, males had a higher mean NC compared to females (P<0.05). Only the group with severe OSA showed a statistically significant difference in the mean NC (P<0.001), comparing the different OSA categories.

The percentage of obesity was 69.8% in the group with OSA, and 67.7% in the normal group. The OSA group had a mean BMI of 34.3±7.5 kg/m^2 compared to 33.6±7.0 kg/m^2 in the normal group (P=0.507). Females with OSA had a significantly higher BMI of 42.1±8.9 kg/m^2 compared to BMI of 33.2±6.5 kg/m^2

in males ($P<0.001$). There were no statistically significant differences in the mean BMI in the different OSA categories.

Witnessed apneas were reported in 85 of 126 (67.5%) subjects in the group with OSA versus 27 out of 65 (41.5%) subjects in the normal group ($P<0.01$). They were reported in 41.5% in the normal group, 63.3% in the mild OSA, 54.2% in the moderate OSA, with the group of severe OSA statistically showing the highest frequency of apneas in 73.6% of the subjects ($P<0.01$). In males with OSA, apneas were noticed in 76 out of 109 (69.7%) subjects versus 9 of 17 (52.9%) females ($P=0.170$).

Awakening with choking was seen in 76 of 126 (60.3%) subjects in the group of OSA versus 31 of 65 (47.7%) subjects in the normal group. ($P=0.096$). It was reported in 47.7% in the normal group, 46.7% in the mild OSA, 54.2% in the moderate OSA group, with the group of severe OSA showing the highest frequency in 68.1% of subjects ($P=0.067$). In males with OSA, choking was reported in 71 of 109 (65.1%) subjects versus 5 of 17 (29.4%) females ($P<0.01$).

The OSA group was associated with a higher mean ESS compared to the normal group ($P<0.001$). Because of the importance of the ESS in referring subjects for PSG, it was further assessed in relation to the four categories of RDI severity. A statistically significant linear increase in mean ESS score was present across all categories of RDI ($P<0.001$) (Table 2). The prevalence of sleepiness as indicated by ESS score ≥11 was seen in 89 of 191 (46.6%) subjects ($P<0.001$). OSA was seen in 74 (83.1%) subjects with sleepiness. In the group with low ESS <11, there were 102 (53.4%) subjects, with 52 (51.0%) subjects with OSA. The frequency of excessive sleepiness at different degrees of RDI were 16.7% in normal group, 14.4% in mild OSA, 12.2% in moderate OSA, 56.7% in severe OSA and consequently, the group with severe OSA showed statistically the highest prevalence ($P<0.001$).

In a multivariate logistic regression analysis (Table 3), sex, age >50 years old, BMI ≥30 kg/m^2, NC >43 cm, ESS ≥11, a history of witnessed apneas and awakening with choking were analyzed. ESS ≥11, male gender, and witnessed apneas were the most important predictors of obstructive sleep apnea.

DISCUSSION

OSA is a common sleep disorder characterized by recurrent episodes of apnea during sleep associated with snoring. Large-scale epidemiological studies have estimated that 4% of males and 2% of females are affected by symptomatic OSAS.[2,10] Researchers estimate that

Table 1. Characteristics of 160 subjects with snoring divided into those with OSA (RDI ≥5) and those without OSA (RDI <5). (Data expressed as mean±SD).

Variable	RDI positive n=126*	RDI negative n=65 *	*P* value
Age* (years)	49.1±9.4	46.2±10.2	0.043
Male*	48.6±9.5	43.7±9.3	0.005
Females	50.3±10.7	51.8±8.2	0.609
BMI (30 kg/m^2)	34.3±7.5	33.6±7.0	0.507
Male	33.2±6.5	31.8±5.8	0.208
Female*	42.1±8.9	36.1±8.0	0.028
NC* (cm)	41.6±3.2	40.0 ±3.6	0.002
Male	41.9±3.0	41.3±3.0	0.241
Female*	39.5±3.5	37.5±3.5	0.069
ESS *	11.6±4.6	7.2±4.2	0.0001
Male*	11.6±4.5	6.7±4.3	0.0001
Female*	10.9±5.0	7.9±4.3	0.044
RDI* (events/hr)	40.9±26.5	1.5±1.3	0.0001
Male* (n=150)	43.0±26.0 (n=109)	1.5 ±1.3) (n=41)	0.0001
Female*(n=41)	27.8±26.5 (17)	1.3 ±1.2) (n=24)	0.001
Arousal Index*	37.8±27.2	15.1±12.3	0.0001

Definitions of abbreviations: BMI: body mass index, NC: neck circumference, RDI: Respiratory disturbance index, ESS: Epworth sleepiness score
* T- test: $P<0.05$ comparing the groups of RDI ≥5 (OSA) versus RDI <5.

Table 2. Relation of associated factors to different categories of RDI (Data expressed as mean±SD).

Characteristic	Normal RDI<5	Mild OSA	Moderate OSA	Severe OSA	*P* value
Age (years)	46.1±10.3	47.8±9.5	49.4±6.5	49.8±10.1	0.171
BMI (kg/m^2)	33.6±7.0	35±7.4	33.8±9.0	34.3±7.0	0.759
NC* (cm)	39.8±3.6	41.2±3.2	40.3±2.4	42.2±3.4	0.001
ESS*	7.2±4.3	9.6±5.0	10.3±4.6	12.6±4.1	0.0001

Definitions of abbreviations: RDI: respiratory disturbance index, BMI: Body mass index, NC: Neck circumference, ESS: Epworth sleepiness score
*(ANOVA test) $P<0.05$ for differences between groups.

Table 3. Predictors of OSA in snorers.

Characteristic	Odds ratio (95% CI)	*P* value
Age ≥50 years	1.84 (0.90-3.75)	0.093
Sex*	3.44 (1.57-7.55)	0.002
BMI ≥30 kg/m2	0.98 (0.45-2.18)	0.974
NC ≥43 cm	1.02 (0.49-2.33)	0.878
ESS≥ 11*	4.35 (2.13-8.90)	000
Witnessed apnea*	2.09 (1.06-4.10)	0.033
Choking	1.12 (0.54-2.33)	0.769

Definitions of abbreviations: BMI: Body mass index, NC: neck circumference, ESS: Epworth sleepiness score
*Multivariate Logistic regression analysis: $P< 0.05$

82% of men and 93% of women with moderate-to-severe OSAS have not been clinically detected or diagnosed.[11] The delay in diagnosis and treatment has led to prolonged morbidity.[12] Furthermore, snoring is a common complaint in patients with OSAS, but by itself does not imply OSAS. Those patients face considerable delays before receiving appropriate treatment for snoring or for OSAS. The current practice guidelines advise referring patients who present with snoring and daytime sleepiness to specialist sleep services for comprehensive investigation using PSG.[1] In our center, subjects with snoring are mostly referred from snoring clinics for PSG, based on their sleepiness score and other risk factors like obesity, increased neck circumference or older age. But in some circumstances, even in the absence of obvious risk factors, PSG is performed based on the physician desire to rule out OSA as a pre-operative assessment in subjects who would undergo surgical treatment for snoring. Qatari subjects are more likely to fall in this category, which may in part explain the lower prevalence of OSA in Qatari snorers in our study.

The frequency of PSG diagnosed OSA indicated by an RDI ≥5 in this selected population of snorers was 72.4%. A significant OSA as indicated by an RDI ≥15 was seen in 50%. The study has shown the expected relation of OSA to male gender, increasing age, BMI, NC, and ESS, although it did not reach statistical significance for BMI.

OSA is expected to have a male to female ratio of 8 to 1.[13] The reason for the lower prevalence of OSA in women than in men is not fully understood. The influence of female sex hormones has been considered, but their exact role in OSA is not clear. Although initial reports emphasized the high prevalence of morbid obesity in women with OSA, as is evident in our study where only in females was obesity related to OSA, reflecting the significantly higher mean BMI compared to males. More recent studies have described OSA in women without significant obesity. The greater central body fat distribution and larger neck dimensions of men may account for some but not all of the sex differences found in OSA prevalence.[14]

Similar to other studies; our study has shown an association between OSA and increased age.[13] Age showed a linear increase across all severity of OSA that did not reach statistical significance.

In considering obesity, approximately 60% to 70% of patients with OSA are obese and a close association between BMI and OSA in adults has been noted in different studies.[15,16] Obesity has been shown to be directly related to the severity of the disease.[17] Contrary to studies that have shown less prevalence of obesity in Asian population,[18] obesity was highly prevalent in the snorers referred for PSG in our center. However, unexpectedly it was not associated with an increased risk or severity of OSA either independently or when controlling for ESS, NC, age or sex. Some studies suggest that OSA may differ by race, reflecting the interplay of various risk factors in different populations, because of differences in environmental and genetic factors.[19] It may be proposed that other factors should be considered before referring obese snorers for PSG in our center.

Increased neck circumference showed an independently linear association to RDI in our study, as is shown in other studies.[20,21] But only the severe OSA group showed a significantly higher mean NC. The effect of NC was not significant when controlling for other factors in the study.

In considering the symptoms of OSA, different studies report conflicting results, with sleepiness and apneas being the most significant while choking and other OSAS symptoms showed less correlation.[22] In our study apnea was witnessed more frequently in OSA group ($P<0.01$), which is expected in a disorder that is commonly reported by the bedroom partner witnessing the loud snoring and periods of complete cessation of breathing in the subject. Choking was reported more frequently in the OSA group but did not reach statistical significance. This may be partly explained by the fact that most of our subjects respond individually to our questionnaire, and choking may be unrecognized with patients usually unaware of the occurrence of "micro-arousals".

ESS was one of the main factors examined extensively in subjects referred for sleep studies with primary complaints of snoring. Excessive daytime sleepiness (EDS) is a common condition, reported by 5% to 12% of adult

subjects in population surveys.[23] EDS has been linked to the OSAS diagnosis in middle-aged populations with mildly elevated RDI. The ESS is commonly used by clinicians to quantify the degree of daytime sleepiness. It measures propensity for daytime sleepiness in adults and at a cutoff score of ≥11, this measure has 94% sensitivity and 100% specificity. While this questionnaire is not specifically diagnostic for OSA, it is a useful indicator of general sleep disorder.[24] However, since daytime sleepiness can result from a number of factors, some investigators have shown that this score may be unreliable in confirming the presence of OSA.[25]

ESS sensitivity ranges from 60% to 65% and specificity ranges from 77% to 80% in predicting OSA.[26,27] The mean ESS in the OSA group was higher than the normal group and progressively increased among all groups of OSA severity in a manner that was highly statistically significant (P=<0.001). The prevalence of excessive daytime sleepiness was noted to be 16.7% in the normal RDI group, which is somewhat similar to the prevalence of 12% to 20% noted in population surveys.[2] Other studies have reported a 21% to 25% prevalence of excessive sleepiness with (ESS ≥11) in subjects with an RDI<5.[23,28]

Young and colleagues 2 have shown that snorers with an RDI <5 are more likely than non-snorers with RDI <5 to report excessive sleepiness. In those patients upper airway resistance syndrome is an expected problem, where repetitive arousals occur in response to partial collapse of the upper airway, despite minimal if any detectable decrease in airflow. Conversely, a high percentage of the population experiences nocturnal apneas and hypopneas without reporting excessive sleepiness, as shown in 26.7% of subjects in our study (Table 3). Furthermore, some subjects with severe OSA may report only a minimal degree of daytime sleepiness.

In patients with OSA, sleep fragmentation by repeated arousals in response to apneas and hypopneas is the apparent cause of excessive sleepiness. Our study has shown significantly higher arousal index in the group of abnormal RDI as compared to subjects with normal RDI (P<0.001). It is likely that arousal from sleep in response to respiratory events explains the association of RDI with sleepiness in our subjects.

Some patients who are seen in the snoring clinic in our hospital are planned for possible surgical procedures as a treatment for snoring if OSA is ruled out. The association with OSA should be recognized preoperatively to avoid the immediate post- operative risk in those patients. Depending on one clinical parameter for referring patients for PSG like ESS carries the risk of missing a significant number of cases, and may lead to prolonged morbidity and health consequences. Some studies have shown that a rank order of symptoms and clinical indicators may help in identifying the cases, which needs urgent evaluation by PSG.[1,29,30] But the possibility of missing cases with OSA even in asymptomatic snorers may still exist, because of the lack of simple measures that help in early referral for PSG.

Portable screening PSG devices are of great help in decreasing the burden on the limited availability of sleep laboratories, and can be used in screening subjects at risk of OSA like snorers, even if clinical indicators are not suggestive of presence of significant OSA.

Our study is limited by the presence of an element of personal clinical judgment in referring subjects for PSG. Yet this pre-selection of the sample has allowed us to identify those factors of importance that may encourage us to review our strategies for referral to a busy PSG unit, e.g. by introducing portable PSG devices as a screening test in our center. The study also presents the polysomnographic diagnosis of OSA, which may not be the actual reflection of the magnitude of OSAS in this study group. The contribution of different risk factors on the severity of OSA was evaluated, but other studies are needed to present those and other factors that are more predictors of symptomatic OSA i.e. OSAS. We did not present our data regarding the association of OSA to other comorbid conditions because those were not the primary concern in referring those subjects and are a matter of detailed discussion in other studies.

In conclusion, snoring is an important risk factor for OSA. Male gender, older age, increased neck circumference and ESS, and a history of witnessed apneas are independent predictors. BMI is an important predictor in females who are morbidly obese but not in male subjects in our center. In a multivariate logistic regression analysis, male gender, sleepiness evaluated by ESS, and witnessed apneas were the most important factors predicting OSA in our study sample. Nevertheless, other factors are to be considered in referring subjects for PSG in high-risk groups like snorers, to avoid the possibility of missing cases in this disabling problem.

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