Diagnostic Accuracy of the Multivariable Apnea Prediction (MAP) Index as a Screening Tool for Obstructive Sleep Apnea

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Abstract

Background and Objective: Obstructive sleep apnea (OSA) is the most common type of sleep-disordered breathing. Multivariable apnea prediction (MAP) index consists of three questions about the frequency of OSA symptoms plus body mass index (BMI), age and sex that categorizes the patients to low and high risk for OSA using a formula. Objective MAP index was calculated by discounting the questions from formula. In this study, we evaluated the utility of the MAP index and objective MAP index in screening of the OSA.

Materials and Methods: In a cross-sectional study, we enrolled 609 patients of three sleep clinics suspected of having OSA who underwent polysomnography (PSG) as a gold standard test for OSA diagnosis. The apnea-hypopnea index (AHI) of the PSG was used to classify the severity of OSA.

Results: A significant strong correlation was observed between MAP index and objective MAP index using Spearman's coefficient (r=0.801, P<0.001). Spearman's correlation coefficient showed a stronger correlation between AHI and MAP index (r=0.586, P<0.001) than between AHI and objective MAP index (r=0.467, P<0.001). The area under the curve of the MAP index and objective MAP index were found to be 0.810 and 0.766, respectively, at AHI≥5; 0.792 and 0.728, respectively, at AHI≥15, and 0.767 and 0.684, respectively, at AHI≥30. The predictive parameters of the MAP index and objective MAP index for identifying OSA were satisfactory.

Conclusions: This study showed that MAP index and especially objective MAP index might have a considerable utility in the screening of OSA.

Keywords: Multivariable apnea prediction index, Screening, Obstructive sleep apnea

Introduction

Obstructive sleep apnea (OSA) is the most common type of sleep-disordered breathing and is characterized by repetitive episodes of apnea and hypopnea during sleep (1). Defined by an apnea-hypopnea index (AHI) ≥5, OSA affects 24% of men and 9% of women in their middle age. However, obstructive sleep apnea syndrome (OSAS) which is defined by an AHI≥5 in addition to daytime sleepiness, affects 4% and 2% of middle-aged men and women, respectively (2).

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Excessive daytime sleepiness is one of the potentially morbid symptoms of OSA that is associated with 2- 7 fold increased risk of car accidents in OSA affected individuals (3). The total proportion of car accidents attributable to driver somnolence has been estimated to be as high as 20% (4). Furthermore, the estimated prevalence of OSA among commercial drivers is 17-28% (5). Therefore, early diagnosis and treatment of OSA in this population could prevent a considerable percentage of accidents. In occupational medicine settings, drivers underreport sleep disorder symptoms, and subjective criteria have low utility in screening and diagnosis of OSA (6). Inevitably, objective tools should be assigned as OSA screening methods in drivers.

Multivariable apnea prediction (MAP) index was introduced in 1995 as a screening tool for OSA (7). It consists of three questions about the frequency of OSA symptoms (snoring or gasping, loud snoring and breathing stops, choke or struggle for breath) body mass index (BMI), age, and sex. The average score of three questions is called index 1. MAP index was calculated according to the following formula; "MAP index= $\frac{e^x}{(1+e)}$ with x = -8.160 + 1.299 * index 1 +0.163 * BMI - 0.028 * index 1 * BMI + 0.032 * Age + 1.27 * Sex, Sex = 1 if male and 0 if female."

In this study, we calculated the objective MAP index by discounting the index 1. Thus, the objective MAP index was calculated by changing the x to "-8.160 + 0.163 * BMI + 0.032 * Age + 1.27 * Sex, Sex = 1 if male and 0 if female".

In this study, we compared diagnostic accuracy between the MAP index and objective MAP index in screening of OSA. Then, we calculated the predictive parameters of the objective MAP index for OSA identification in AHI above the threshold of 30.

Materials and Methods

A cross-sectional study was performed among 609 patients visiting 3 sleep clinics during October 2009- November 2012 in Tehran. Patients suspected of having OSA underwent polysomnography (PSG) to confirm the OSA diagnosis. In the morning after performing the PSG, patients filled out a questionnaire that included three questions of index 1. Weight, height, neck circumference, systolic, and diastolic blood pressure were measured by technicians. Informed consent was obtained from all participants. The study was approved by institutional review board of the Tehran University of Medical Sciences.

Polysomnography

PSG is the gold standard test for OSA diagnosis. Patients went to bed at their own usual bedtime. Electroencephalogram, electrocardiogram, electro-oculogram, electromyogram (submental and bilateral anterior tibialis), snoring, arterial oxygen saturation, abdominal and thoracic respiratory efforts, oro-nasal pressure and body position were monitored during sleep. Video monitoring recorded patients' sleep by infrared beams (8). AHI derived from PSG, was determined for conducting subgroup analysis of patients. An apnea was defined as total cessation of airflow for at least 10 seconds, whereas hypopnea was defined as the reduction of airflow for at least 10 seconds with 3% reduction of arterial oxygen saturation or with arousal. AHI was calculated by dividing sum of apnea and hypopnea by hours of sleep. AHI equal or more than 5 was considered as the clinical diagnosis of OSA while 5≤ AHI <15, 15≤ AHI <30 and AHI ≥ 30 were defined as mild, moderate, and severe OSA, respectively. All tests were analyzed by the first author (certified by board of registered polysomnographic technologists) according to the recommended criteria by the American Academy of Sleep Medicine (9).

Statistical Analysis

Spearman's correlation coefficient was used for assessing the correlation between MAP index and objective MAP index, AHI and MAP index and between AHI and objective MAP index. Using ROC curve analysis, we computed the area under the curve (AUC) and the cut-offs with highest average of specificity and sensitivity for the MAP index and objective MAP index in OSA identification using the AHI thresholds of 5, 15 and 30. Then we calculated predictive parameters of the MAP index and objective MAP index including sensitivity, specificity, likelihood ratios (LR+ and LR) and odds ratio (OR). PASW statistics 18 and MedCalc version 12.2.1.0 were used for statistical analysis.

Results

A total of 609 patients participated in the

Table 1. Characteristics of studied patients.

	All patients (n=609)
Female (%)	25.2
Age (years)	45.9 ± 13.1
BMI (kg/m^2)	29.48 ± 5.9
Neck circumference (cm)	39.75 ± 3.8
Systolic blood pressure (mmHg)	119.71 ± 14.7
Diastolic blood pressure (mmHg)	78.66 ± 12.1
Apnea hypopnea index	27.64 ± 29.8
Mean SaO_2	91.91 ± 4.6
Lowest SaO_2	69.8 ± 27.9
Sleep efficiency	74.32 ± 14.3
MAP index	0.52 ± 0.24
Objective MAP index	0.31 ± 0.19

BMI: body mass index, SaO_2: arterial O_2 saturation, MAP: multivariable apnea prediction
All characteristics are given as mean ± standard deviation except female that is given as percent

Table 2. Predictive parameters of the MAP index and objective MAP index in AHI thresholds of 5, 15 and 30

AHI threshold	Tool	Cutoff	AUC	Sensitivity	Specificity	LR+	LR-
5	MAP	0.46	0.810	76.8 (71.2-82)	71.8 (62.1-80.3)	2.7 (2.4-3.1)	0.3 (0.2-0.5)
	Objective MAP	0.22	0.766	71 (66.2-75.6)	70.4 (62.5-77.7)	2.4 (2.1-2.7)	0.4 (0.3-0.6)
15	MAP	0.48	0.792	83.3 (77.1-88.5)	64.3 (56.8-71.5)	2.3 (2.1-2.7)	0.2 (0.2-0.4)
	Objective MAP	0.23	0.728	76.7 (71.3-81.6)	59.8 (53.5-65.9)	1.9 (1.7-2.2)	0.4 (0.3-0.5)
30	MAP	0.65	0.767	61.8 (52.5-70.6)	79.2 (73.5-84.2)	2.9 (2.5-3.5)	0.4 (0.3-0.7)
	Objective MAP	0.24	0.684	75.9 (69.1-82)	52 (46.6-57.4)	1.5 (1.4-1.8)	0.4 (0.3-0.6)

MAP: multivariable apnea prediction, AHI: apnea-hypopnea index, AUC: area under the curve, LR+: likelihood ratio of a positive test result, LR-: likelihood ratio of a negative test result

study. Characteristics of patients are shown in Table 1.

According to the PSG, 171 patients (28.2%) had AHI<5, whereas the remaining 438 patients had mild (n = 125, 20.5%), moderate (n = 112, 18.3%) and severe (n = 201, 33%) OSA.

Spearman's correlation coefficient revealed a good correlation between MAP index and objective MAP index (r=0.801. *P*<0.001). Moreover, a moderate Spearman's correlation was observed between AHI and MAP index and objective MAP index. This correlation was stronger between AHI and MAP index (r=0.586, *P*<0.001) than between AHI and objective MAP index (r= 0.467, *P*< 0.001).

Predictive parameters of the MAP index and objective MAP index in the cut-offs with the highest average of sensitivity and specificity for predicting mild, moderate and severe OSA are shown in Table 2. The AUC

Table 3. Predictive parameters of the objective MAP index for OSA identification in AHI threshold of 30

Objective MAP cutoff	Sensitivity	Specificity	LR+	LR-	OR
>0.10	97.27 (93.7 - 99.1)	17.63 (13.8 - 22.1)	1.18 (0.9 - 1.5)	0.15 (0.1 - 0.4)	7.46 (2.9 - 18.9)
>0.15	88.52 (83.0 - 92.8)	29.77 (25.0 - 34.9)	1.26 (1.1 - 1.5)	0.39 (0.3 - 0.6)	3.45 (2 - 5.8)
>0.20	79.78 (73.2 - 85.3)	44.51 (39.2 - 49.9)	1.44 (1.3 - 1.7)	0.45 (0.3 - 0.6)	3.27 (2.1 - 4.9)
>0.25	73.22 (66.2 - 79.5)	52.89 (47.5 - 58.2)	1.55 (1.4 - 1.8)	0.51 (0.4 - 0.7)	3.05 (2 - 4.5)
>0.30	63.93 (56.5 - 70.9)	63.01 (57.7 - 68.1)	1.73 (1.5 - 2.0)	0.57 (0.5 - 0.7)	2.98 (2 - 4.3)
>0.35	52.46 (45.0 - 59.9)	69.94 (64.8 - 74.7)	1.75 (1.5 - 2.0)	0.68 (0.5 - 0.8)	2.62 (1.8 - 3.8)
>0.40	39.89 (32.7 - 47.4)	77.75 (73.0 - 82.0)	1.79 (1.5 - 2.2)	0.77 (0.6 - 1.0)	2.28 (1.5 - 3.3)
>0.45	35.52 (28.6 - 42.9)	84.97 (80.8 - 88.6)	2.36 (1.9 - 2.9)	0.76 (0.6 - 1.0)	3.11 (2 - 4.7)
>0.50	27.32 (21.0 - 34.4)	91.62 (88.2 - 94.3)	3.26 (2.6 - 4.1)	0.79 (0.6 - 1.1)	3.96 (2.4 - 6.5)
>0.60	15.30 (10.4 - 21.3)	95.95 (93.3 - 97.8)	3.78 (2.7 - 5.3)	0.88 (0.5 - 1.5)	3.98 (2 - 7.6)
>0.70	9.29 (5.5 - 14.5)	97.98 (95.9 - 99.2)	4.59 (2.9 - 7.2)	0.93 (0.4 - 1.9)	5.28 (2.1 - 12.8)
>0.80	3.83 (1.6 - 7.7)	98.84 (97.1 - 99.7)	3.31 (1.6 - 6.8)	0.97 (0.4 - 2.6)	3.9 (1.1 - 13.1)
>0.90	1.64 (0.3 - 4.7)	100 (98.9 - 100.0)		0.98 (0.9 - 1)	

OSA: obstructive sleep apnea, AHI: apnea hypopnea index, LR+: likelihood ratio of a positive test result, LR-: likelihood ratio of a negative test result, OR: odds ratio of the MAP index and objective MAP index were found to be 0.810 and 0.766, respectively, for identifying mild OSA, 0.792 and 0.728, respectively, for identifying moderate OSA, and 0.767 and 0.684, respectively, for identifying severe OSA.

In AHI above the threshold of 30, we calculated the predictive parameters of the objective MAP index in cutoffs ranging from 0.10- 0.90 (Table 3).

Discussion

Subjective instruments for screening of OSA in drivers had not shown an acceptable performance because of the propensity of drivers for minimization of their symptoms or unawareness of their disease (10). In this study, participants filled in the Iranian version of Epworth Sleepiness Scale (ESS) (11). The average ESS scores of patients with mild, moderate, and severe OSA were 9.4 ± 5.5, 11.7 ± 6.3 and 12.1 ± 6.2 meaning that patients with more severity of OSA had higher ESS score. Nonetheless, it is reported that the ESS score do not increase in the severe grades of OSA in the population of drivers visiting the occupational medicine clinics (6).

Prevalence of the OSA in sleep clinic patients is higher than commercial drivers. In current study, 71.8 % of patients had OSA while it was estimated that up to 28% of drivers could have OSA (5). In the sensitivity analysis, only the positive and negative predictive values are dependent to the prevalence of disease. Thus, in present study we did not compute the predictive values of the MAP index and objective MAP index.

Several studies have found that higher severity of OSA is associated with an increased risk for motor vehicle accidents (12-14). Therefore, we analyzed the predictive parameters of the objective MAP index with cut-offs ranging from 0.10-0.90 for predicting the OSA in AHI above the threshold of 30. As presented in Table 3, by raising the cutoff of the objective MAP index, the sensitivity decreases while the specificity increases. With a cutoff resulting in higher sensitivity and lower specificity, the larger proportion of patients would be recognized as high risk for OSA and probably some of the drivers that did not have OSA could have undergone PSG whereas with a cutoff resulting in higher specificity and lower sensitivity, the smaller proportion of patients would be recognized as high risk for OSA and probably some of the OSA affected patients were recognized as low risk for OSA and did not undergo PSG.

The objective MAP index cutoff with the highest average of sensitivity and specificity for predicting severe OSA is 0.24. In a setting where it is important that most of the drivers that be recognized as high risk and underwent PSG have OSA, the cutoff resulting to higher specificity is preferred. Enormous cost of the PSG might be a logical obstacle in this setting.

An important limitation of this study is the population of sleep clinic patients for whom we evaluated the utility of objective MAP index for predicting OSA. We chose this population because the majority of patients in sleep clinics undergo PSG as the gold standard test for diagnosing OSA. As mentioned above, only the negative and positive predictive values of the objective MAP index are not similar in sleep clinic patients and commercial drivers. Therefore, we relied on the sensitivity and specificity for analysis of current data.

This study showed there is a good correlation between objective MAP index and MAP index, so that the objective MAP index might have a considerable utility in the screening of OSA in drivers. Further studies are needed to evaluate its utility in the population of commercial drivers.

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