Physical Examination: Mallampati Score as an Independent Predictor of Obstructive Sleep Apnea

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Study Objective: To assess the clinical usefulness of the Mallampati score in patients with obstructive sleep apnea. Mallampati scoring of the orophyarynx is a simple noninvasive method used to assess the difficulty of endotracheal intubation, but its clinical usefulness has not been validated in patients with sleep-disordered breathing.
Design: Prospective multivariate assessment of a predictor variable.
Setting: The UCSF Sleep Disorders Center.
Patients or Participants: One hundred thirty-seven adult patients who were evaluated for possible obstructive sleep apnea.
Interventions: Prospective determination of the Mallampati score, assessment of other variables for multivariate analysis, and subsequent overnight polysomnography.
Measurements and Results: The Mallampati score was an independent predictor of both the presence and severity of obstructive sleep apnea. On average, for every 1-point increase in the Mallampati score, the odds of having obstructive sleep apnea (apnea-hypopnea index ≥ 5) increased more than 2-fold (odds ratio [per 1-point increase] = 2.5; 95% confidence interval: 1.2-5.0; p = .01), and the apnea-hypopnea index increased by more than 5 events per hour (coefficient = 5.2; 95% confidence interval: 0.2-10; p = .04). These results were independent of more than 30 variables that reflected airway anatomy, body habitus, symptoms, and medical history.
Conclusions: Our results indicate that Mallampati scoring is a useful part of the physical examination of patients prior to polysomnography. The independent association between Mallampati score and presence and severity of obstructive sleep apnea suggests that this scoring system will have practical value in clinical settings and prospective studies of sleep-disordered breathing.
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INTRODUCTION

OBSTRUCTIVE SLEEP APNEA (OSA) MAY AFFECT AS MANY AS 1 IN 5 ADULTS AND HAS THE POTENTIAL FOR CAUSING SERIOUS LONG-TERM HEALTH consequences, including cardiovascular disease, hypertension, and stroke and a reduced quality of life.[1-6] Despite years of research into the causes and consequences of OSA, the early identification of patients who are most at risk remains challenging. Airway variables that are associated with OSA have been incorporated into complex models involving detailed physical or radiographic measurements of the face, jaw, and oral cavity[7-10] that are difficult to apply in clinical settings. Terms used to describe the physical examination of the airway, such as "crowded," "narrow," or "low-lying," are frequently imprecise or subject to interpretation. Additionally, most airway characteristics have not been subjected to a multivariate analysis with extensive adjustments for possible confounding variables, a crucial validation process needed prior to widespread clinical utilization.

The Mallampati score, derived from a simple airway-classification system, has been used to identify patients at risk for difficult tracheal intubation for more than 20 years.[11-15] The system is noninvasive and simple to learn, and it requires no special equipment. Prior studies have reported the unadjusted associations between a standard Mallampati score and OSA[16-18] or the associations after controlling for specific variables such as ethnicity, neck circumference, and body mass index.[19] The usefulness of this system, however, has not been validated by a rigorous multivariate analysis, with extensive adjustments for body habitus, symptoms, and medical history. Therefore, in this prospective study, we sought to validate the clinical usefulness of the Mallampati score by examining the association between Mallampati score and OSA, after adjustments for a large number of potentially confounding variables.

METHODS

Patients

Patients of at least 18 years of age referred to the University of California, San Francisco Sleep Disorders Center and evaluated for possible OSA were eligible for the study. These patients represented a convenience sample studied over a 6-month period. Patients who had prior otolarnygologic surgery or radiofrequency procedures, who were consistently using continuous positive airway or bilevel pressure or who required oxygen during polysomnography were excluded.

All measurements, including the Mallampati score, were made prior to polysomnography as part of a routine clinical assessment. Chart review was utilized to obtain the results of polysomnography and to confirm variables. Approval for the study, which included the use of information and the review of clinical notes and medical records, was obtained from the UCSF institutional review board.

Disclosure Statement
This was not an industry supported study. Drs. Nuckton, Glidden, Browner, and Claman have indicated no financial conflicts of interest.

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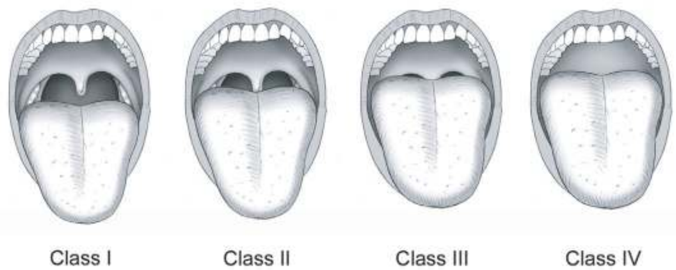

Figure 1—Mallampati Airway Classification (I-IV Scale). During assessment, the patient is instructed to open his or her mouth as wide as possible, while protruding the tongue as far as possible. Patients are instructed to not emit sounds during the assessment. Class I: soft palate and entire uvula visible; Class II: soft palate and portion of uvula visible; Class III: soft palate visible (may include base of uvula); Class IV: soft palate not visible

Measurements

The Mallampati score was obtained during the physical examination of each patient. For all patients, the assessment of scores was done or directly supervised by the same physician. The score was assessed by asking the patient to open his or her mouth as wide as possible, while protruding the tongue as far as possible. The patient was instructed to not emit sounds during the assessment. A standard I to IV grading system was used (Figure 1).[13-15] A modified Mallampati score, obtained without protruding the tongue[20,21] but that is otherwise identical to standard scoring, was also assessed. All patients subsequently underwent either inpatient (SensorMedics; Yorba Linda, CA) or home (Nellcor Puritan Bennett (Edentrace without electroencephalogram; Ottawa, ON) polysomnography. In both types of studies, thermistors were used to quantify airflow. The polysomnogram results were assessed and scored by an experienced sleep polysomnographic technician who was unaware of the study hypothesis.

We also ascertained characteristics similar to those measured in other studies of OSA, as well as others with potential clinical importance.[1-6,9,10,18,20-27] Historical variables included a history of snoring (none, mild, moderate, severe), witnessed apnea (none, some nights, most nights, all nights), gasping episodes or sudden awakening (none, some nights, most nights, all nights), number of daily unintentional dozing episodes (number per day), morning headache (none, some nights, most nights, all nights), and family history of OSA. The Epworth Sleepiness Scale was used to assess subjective sleepiness.[28,29] This score is based on a questionnaire in which patients are asked to rate how likely they are to fall asleep during several situations. Scores range from 0 to 24, and higher scores indicate a higher propensity toward daytime sleepiness.

Medical history variables included medically treated hypertension, diabetes, hypothyroidism, gastroesophageal reflux, sinusitis or rhinitis, cerebrovascular accident, dementia, Parkinson disease, obstructive lung disease, coronary artery disease, congestive heart failure, dysrhythmia, depression, antidepressant use, HIV status, tobacco use (current use and total pack-years), alcohol consumption (drinks per day), and prior alcohol abuse. Other measurements included neck circumference (cm), body mass index (kg/m^2), tonsil size (0-IV),[20,21] and degree of overjet (mm).

The primary outcome variables were OSA and the apnea-hypopnea index (AHI), as determined by polysomnography. OSA was defined as an AHI of 5 or greater.[1,30] The AHI refers to the total number of episodes of either cessation (apnea) or decrease in airflow (hypopnea) per hour.[30] Apnea was determined by a cessation of airflow for 10 or more seconds; hypopnea was determined by a decrease in airflow combined with a 4% or greater decrease in oxygen saturation.

Statistical Analysis

Multiple logistic regression was used to identify the variables that were independently associated with the presence of OSA. Each variable with a significant association ($p < .05$) by bivariate regression was included in a multiple-variable regression model. The area under a receiver- operator curve was calculated for each significant bivariate logistic regression variable, and likelihood ratios were calculated for each Mallampati score.

Only 1 patient had Parkinson disease, and only 1 patient had dementia; neither had OSA, and these variables were not included in the final analysis. The goodness of fit of the logistic regression model was assessed with the Hosmer-Lemeshow test[31] and a receiver-operator curve for the multivariable model was generated. Multiple linear regression was used to identify the variables that were independently associated with the AHI on a continuous scale. Pearson product-moment and Spearman rank correlations, and χ^2 tests were used to examine the relationships between variables. Because Mallampati scoring was done or supervised by the same physician for all patients, interrater reliability was not assessed.

Several alternative analyses were done. The modified version of the Mallampati score, (without protrusion of the tongue) and a version of the Mallampati system that was scored on a scale of I to III instead of I to IV (categories III and IV combined into a single category) were substituted for the standard Mallampati score in multivariate logistic-regression models. Finally, we modeled the associations of both Mallampati score and neck circumference, with alternate definitions of OSA (AHI ≥ 10, ≥ 15, and ≥ 20). STATA computer software (Version 9.1; College Station, TX) was used for the analyses.

RESULTS

We studied 137 patients with suspected OSA and who had been referred to the University of California Sleep Disorders Center (Table 1). Overall, 80 (58%) of 137 patients had OSA as defined by an AHI of 5 or greater. The AHI for all patients ranged from 0 to 126, with a mean ± SD of 18.1 ± 24.6.

Several variables were associated with an increased risk of OSA (Table 2). The proportion of patients with OSA, the likelihood ratios for OSA, and the AHI as measured on a continuous scale, all increased with greater Mallampati scores (Figure 2). OSA was present in 4 of 12 patients with Mallampati Class I (likelihood ratio = 0.4), 24 of 50 patients with Mallampati Class II (likelihood ratio = 0.7), 45 of 65 patients with Mallampati Class III (likelihood ratio = 1.6), and 7 of 10 patients with Mallampati Class IV (likelihood ratio = 1.7).

In a multivariate model, Mallampati score was independently associated with an increased risk of OSA (Table 3). For every 1-point increase in the Mallampati score, the odds of having OSA increased by more than 2-fold (odds ratio [per 1-point increase] = 2.5; 95% confidence interval: 1.2, 5.0; p = .01). The Hosmer-Lemeshow test indicated that the fit of the multiple logistic regression model was good (p = .34), and the area under the receiver-operator curve for the model was 0.86. Neck circumference,

Table 1—Clinical Characteristics of 137 Patients Assessed for Possible Obstructive Sleep Apnea[a]

Characteristic	Results
Age, y	46 ± 12
Men, %	99 (72)
Mallampati score[b]	
Mean	2.5 ± 0.8
Class I	12 (9)
Class II	50 (36)
Class III	65 (47)
Class IV	10 (7)
Body mass index, kg/m^2	31.3 ± 6.9
Neck circumference, cm	40.9 ± 3.6
Overjet, mm	3.6 ± 2.3
ESS score (0-24)[c]	10.4 ± 5.2
History of snoring	129 (94)
History of witnessed apnea	85 (63)
History of gasping/sudden awakening	55 (40)
History of unintentional dozing	42 (31)
Medical history	
Hypertension	29 (21)
Sinusitis/Rhinitis	25 (18)
Depression	35 (26)
Hypothyroidism	12 (9)
Gastroesophageal reflux	10 (7)
Diabetes mellitus	10 (7)
Cerebrovascular accident	4 (3)
Cardiac disease[d]	11 (8)
Obstructive lung disease	22 (16)
Parkinson disease	1 (<1)
Dementia	1 (<1)
HIV positive	7 (5)

[a]Data are presented as mean ± SD or number (percentage); data are missing for neck circumference in 3 patients, for Epworth Sleepiness Scale (ESS) score in 1 patient, and for witnessed apnea in 1 patient. Ninety-four patients (69%) were assessed by inpatient polysomnography; the others were assessed by home polysomnography.
[b]Standard Mallampati score assessed with tongue protruded. A modified Mallampati score (assessed without tongue protruded) was also obtained (Class I: n = 7 [5%]; Class II: n = 32 [23%]; Class III: n = 84 [61%]; Class IV: n = 14 [10%]).
[c]The ESS score is based on a questionnaire in which patients are asked to rate how likely they are to fall asleep during several situations. Scores range from 0-24; higher scores indicate a greater propensity toward daytime sleepiness.
[d]Cardiac disease includes coronary artery disease, heart failure, and dysrhythmia.

witnessed apnea, and hypertension were the only other variables that were independently associated with an increased risk of OSA (Table 3).

The substitution of a modified Mallampati score, in which the tongue was not protruded, yielded similar results (odds ratio [per 1-point increase] = 2.1; 95% confidence interval: 1.0, 4.3; p = .04). The Mallampati scale of I to III was also independently predictive (odds ratio [per 1-point increase] = 2.8; 95% confidence interval: 1.3, 6.0; p = .01). Finally, in models that also included neck circumference, Mallampati score was predictive of OSA defined by an AHI ≥ 10 (odds ratio [per 1-point increase] = 1.8; 95% confidence interval: 1.0, 3.1; p = .04), an AHI ≥ 15 (odds ratio [per 1-point increase] =1.8; 95% confidence interval: 1.0, 3.1; p = .04), and an AHI ≥ 20 (odds ratio [per 1-point increase] =2.1; 95% confidence interval: 1.1, 3.8; p = .02) (Table 4).

Table 2—Variables Associated with an Increased Risk of Obstructive Sleep Apnea[a]

Variable (95% CI)	Odds Ratio	p value	Area under ROC curve
Mallampati Score (I-IV), per 1-point increase	2.0 (1.2, 3.2)	< .01	0.63
Age, per 10-y increase	1.5 (1.1, 2.0)	.01	0.65
Male Sex	2.2 (1.0, 4.6)	.05	0.58
Body mass index, per 5-kg/m^2 increase	1.5 (1.1, 1.9)	.01	0.65
Neck circumference, per 2.5-cm increase	2.0 (1.4, 2.7)	< .01	0.73
ESS score, per 5-point increase	1.4 (1.0, 2.0)	.04	0.60
Dozing episodes, per episode/day increase	1.9 (1.1, 3.4)	.02	0.61
Witnessed apnea[b] episode/day increase	1.8 (1.3, 2.6)	< .01	0.67
Gasping/sudden awakening[b]	1.6 (1.0, 2.5)	.04	0.60
Hypertension	3.4 (1.3, 9.1)	.01	0.59

[a]Unadjusted (bivariate) associations. Having obstructive sleep apnea was defined as having an apnea-hypopnea index ≥5. CI refers to confidence interval; ROC, receiver-operator curve; ESS, The Epworth Sleepiness Scale score, based on a questionnaire in which patients are asked to rate how likely they are to fall asleep during several situations (scores range from 0-24; higher scores indicate a greater propensity toward daytime sleepiness).
[b]Categories included none, some nights, most nights, all nights.

The Mallampati score was also associated with the AHI on a continuous scale (Table 5). For every 1-point increase in Mallampati score, the AHI increased by more than 9 events per hour in the bivariate analysis and by more than 5 events per hour in the multivariate analysis. Age, neck circumference, and severity of witnessed apnea were also independently associated with the AHI (Table 5).

There were no significant associations between Mallampati score and either body mass index (p = .2), tonsil size (p = .3), use of home polysomnography (p = .7), or patient age (p = .9); there were significant but modest associations between Mallampati score and neck circumference (r = 0 .19; p = .03) and Mallampati score and degree of overjet (r = 0 .21; p = .01).

DISCUSSION

We were able to validate the clinical usefulness of the Mallampati score in patients with OSA. This scoring system, which is noninvasive and can be rapidly mastered and assessed in seconds, was associated with both the presence and severity of OSA. On average, for every 1-point increase in Mallampati score, the odds of having OSA increased more than 2-fold and the AHI increased by more than 5 events per hour. Moreover, these associations were independent of all other variables that we measured, including history of snoring, overjet, tonsil size, neck circumference, and body mass index.

The Mallampati score is used by anesthesiologists to assess the difficulty of endotracheal intubation. Presumably, the angle between the base of the tongue and larynx determines, at least par-

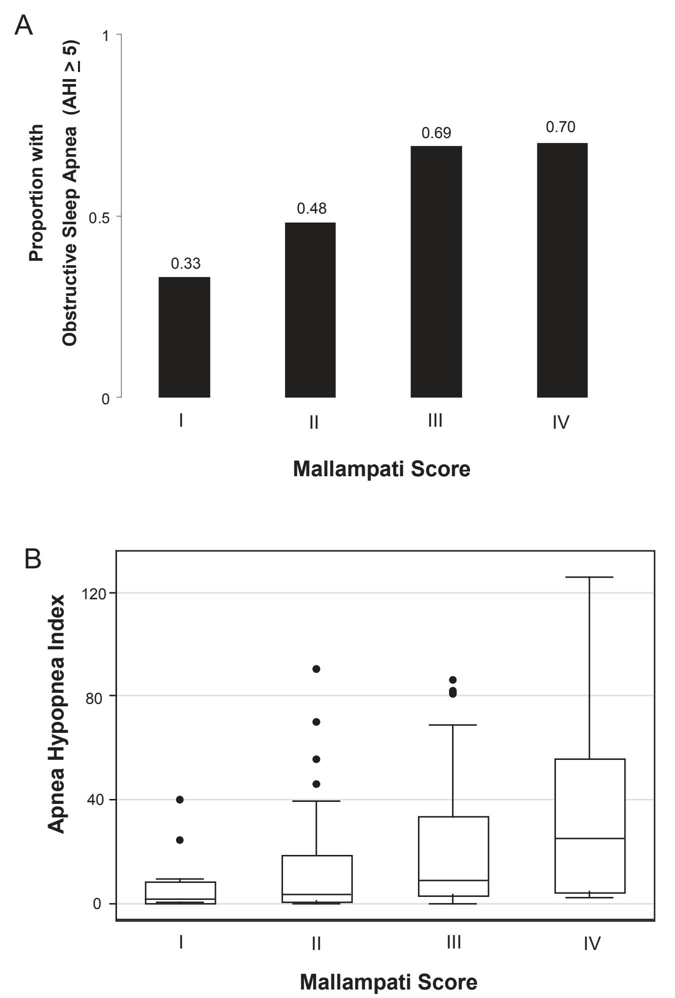

Figure 2—Relationship Between Mallampati Score (I-IV Scale) and Obstructive Sleep Apnea. A. The Mallampati Score (I-IV Scale) vs the proportion of patients with obstructive sleep apnea (OSA) (apnea hypopnea index [AHI] ≥ 5). OSA present in 4 of 12 patients with Class I (likelihood ratio =0.4), 24 of 50 patients with Class II (likelihood ratio =0.7), 45 of 65 patients with Class III (likelihood ratio =1.6), and 7 of 10 patients with Class IV (likelihood ratio =1.7).
B. The Mallampati Score (I-IV Scale) vs AHI on a continuous scale. AHI values ranged from 0-126. Standard box plot for each Mallampati score, in which the line in the middle of the box represents the median, the box extends from the 25th percentile to the 75th percentile (interquartile range), the whiskers extend to the upper and lower adjacent values (defined by a maximum of 1.5 × the interquartile range), and points represent outliers.

Table 3—Variables Independently Associated With an Increased Risk of Obstructive Sleep Apnea[a]

Variable	Odds Ratio (95% CI)	p value
Mallampati score, (I-IV) (per 1-point increase)	2.5 (1.2, 5.0)	.01
Neck circumference, (per 2.5-cm increase)	1.9 (1.0, 3.5)	.04
Witnessed apnea[b]	1.9 (1.2, 3.1)	< .01
Hypertension	4.9 (1.2, 20)	.03

[a]Results from multivariable analysis (all variables from Table 2 included). Having obstructive sleep apnea was defined as having an apnea-hypopnea index ≥5. CI refers to confidence interval; ROC, receiver-operator curve.
[b]Categories included none, some nights, most nights, all nights.

Table 4—Associations Between Mallampati Score[a], per 1-Point Increase, and Alternate Apnea-Hypopnea Index Cutoffs

AHI	Odds Ratio (95% CI)	p value
≥ 10	1.8 (1.0, 3.1)	.04
≥ 15	1.8 (1.0, 3.1)	.04
≥ 20	2.1 (1.1, 3.8)	.02

[a]Results from limited multivariable analysis (Mallampati score [I-IV], neck circumference, and each apnea-hypopnea index [AHI] cutoff). CI refers to confidence interval.

tially, the accessibility of the larynx; by inference, when the base of the tongue is disproportionately large, or the oropharyngeal cavity is disproportionately small, the tongue masks the visibility of the faucial pillars and uvula.[11,12] These factors could also apply to the risk of OSA. Indeed, an association between difficulty of tracheal intubation and OSA has been reported.[16] Other variables, including neck circumference, witnessed apnea, and medically treated hypertension, were also associated with OSA, consistent with prior reports.[2,6,23,26]

The original Mallampati score was based on a scale of I to III,[11,12] but, over time, has evolved into the I to IV scoring system[13-15] used commonly by anesthesiologists today. In our study, the proportions of patients with OSA were similar in those with a Mallampati score of III or IV. However, the average AHI was higher in patients with a Mallampati score of IV, and, in our regression models, both the AHI and the odds of having OSA increased as Mallampati score increased. The Mallampati score can also be assessed without protrusion of the tongue. Two studies have reported unadjusted associations between OSA and this modified version of the score,[20,21] which is perhaps more reflective of obstruction caused by the tongue during sleep.Regardless, all of these versions were independently predictive of the presence of OSA in our study.

All patients in our study had been referred for evaluation. Thus, clinicians presumably had some suspicion of having OSA or sleep-disordered breathing prior to referral. Mallampati scoring may not be as useful among patients with a lower probability of having OSA. Because Mallampati scoring was done or supervised by a single physician, interrater reliability was not assessed. We did not assess ethnicity in our study, although a previous study has suggested that Mallampati score may have utility in Asian patients.[19] Odds ratios in our study were not equivalent to risk ratios because the outcome was common, and the likelihood ratios for each Mallampati score were modest, as occurs with the physical examination techniques for a variety of medical problems.[32-36] For these reasons, we remain cautious about the use of the Mallampati score as a simple diagnostic test.

However, given the great simplicity of Mallampati scoring, and the independent nature of the relationship between the Mallampati score and OSA, this score has potential value for facilitating and standardizing communication among clinicians who care for patients with OSA. Mallampati scoring could also be used to prioritize patients for polysomnography, an important consideration given the large backlog of patients awaiting assessment for OSA.[37-40]

Mallampati scoring may have value when used in clinical trials because surgical or other treatment benefits could vary by Mallampati score. Such scoring may facilitate more consistent

Table 5—Variables Associated with the Apnea-Hypopnea Index (Continuous Scale)

Variable	Bivariate Coefficient* (95%CI†)	Bivariate P value	Mulitvariate Coefficient* (95%CI†)	Mulitvariate P value
Mallampati score	9.3 (4.0, 15)	< .01	5.2 (0.2, 10)	.04
Age, y	0.4 (0.0, 0.7)	.03	0.3 (0.04, 0.6)	.03
Body mass index, kg/m^2	1.1 (0.5, 1.7)	< .01	0.3(-0.3, 0.9)	.4
Neck circumference, cm	3.0 (1.9, 4.1)	< .01	1.9 (0.7, 3.1)	< .01
Dozing episodes, no./day	6.2 (1.1, 11)	.02	3.6 (-1.0, 8.3)	.1
Witnessed apnea[b]	7.9 (4.4, 11)	<.01	4.2 (0.6, 7.8)	.02
Gasping/ sudden awakening[b]	8.1 (3.4, 13)	<.01	3.2 (-1.4, 7.9)	.2
Snoring[c]	7.0 (2.4, 12)	<.01	3.5 (-1.0, 8.0)	.1

[a]For every 1-point increase in each variable (units designated in parentheses), the apnea-hypopnea index (events/h) increases by the amount of the coefficient. CI refers to confidence interval.
[b]Categories included none, some nights, most nights, all nights.
[c]Categories included none, mild, moderate, severe.

applications of treatments and improve stratification during the analysis of trial outcomes, with little or no increase in trial cost or complexity.

In summary, our results indicate that the Mallampati score, while having limitations as a diagnostic test, is a useful part of the physical examination of patients prior to polysomnography. The independent association between Mallampati score and the presence and severity of OSA suggests that this scoring system will have practical value in clinical settings and in prospective studies of sleep-disordered breathing.

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REFERENCES

1. Young T, Palta M, Dempsey J, Skatrud J, Weber S, Badr S. The occurrence of sleep disordered breathing among middle-aged adults. N Engl J Med 1993;328:1230-5.
2. Peppard PE, Young T, Palta M, Skatrud J. Prospective study of the association between sleep-disordered breathing and hypertension. N Engl J Med 2000;342:1378-84.
3. Bixler EO, Vgontzas AN, Lin HM, et al. Prevalence of sleep-disordered breathing in women: effects of gender. Am J Respir Crit Care Med 2001;163:608-13.
4. Shahar E, Whitney CW, Redline S, et al. Sleep-disordered breathing and cardiovascular disease: cross-sectional results of the Sleep Heart Health Study. Am J Respir Crit Care Med 2001;163:19-25.
5. Malhotra A, White DP. Obstructive sleep apnoea. Lancet 2002;360:237-45.
6. Young T, Skatrud J, Peppard PE. Risk factors for obstructive sleep apnea in adults. JAMA 2004;291:2013-6.
7. Lowe AA, Fleetham JA, Adachi S, Ryan CF. Cephalometric and computed tomographic predictors of obstructive sleep apnea severity. Am J Orthod Dentofacial Orthop 1995;107:589-95.
8. Kushida CA, Efron B, Guilleminault C. A predictive morphometric model for the obstructive sleep apnea syndrome. Ann Intern Med 1997;127:581-7.
9. Shepard JW, Jr., Gefter WB, Guilleminault C, et al. Evaluation of the upper airway in patients with obstructive sleep apnea. Sleep 1991;14:361-71.
10. Goldberg AN, Schwab RJ. Identifying the patient with sleep apnea: upper airway assessment and physical examination. Otolaryngol Clin North Am 1998;31:919-30.
11. Mallampati SR. Clinical sign to predict difficult tracheal intubation (hypothesis). Can Anaesth Soc J 1983;30:316-7.
12. Mallampati SR, Gatt SP, Gugino LD, et al. A clinical sign to predict difficult tracheal intubation: a prospective study. Can Anaesth Soc J 1985;32:429-34.
13. Samsoon GL, Young JR. Difficult tracheal intubation: a retrospective study. Anaesthesia 1987;42:487-90.
14. Benumof JL. Management of the difficult adult airway. With special emphasis on awake tracheal intubation. Anesthesiology 1991;75:1087-110.
15. Pollard BJ, Norton ML. Principles of Airway Management. In: Healy TEJ, Knight PR, eds. Wilie and Churchill-Davidson's A Practice of Anesthesia, 7th ed. London: Arnold/Hodder Headline; 2003.
16. Hiremath AS, Hillman DR, James AL, Noffsinger WJ, Platt PR, Singer SL. Relationship between difficult tracheal intubation and obstructive sleep apnoea. Br J Anaesth 1998;80:606-11.
17. Liistro G, Rombaux P, Belge C, Dury M, Aubert G, Rodenstein DO. High Mallampati score and nasal obstruction are associated risk factors for obstructive sleep apnoea. Eur Respir J 2003;21:248-52.
18. Tsai WH, Remmers JE, Brant R, Flemons WW, Davies J, Macarthur C. A decision rule for diagnostic testing in obstructive sleep apnea. Am J Respir Crit Care Med 2003;167:1427-32.
19. Lam B, Ip MS, Tench E, Ryan CF. Craniofacial profile in Asian and white subjects with obstructive sleep apnoea. Thorax 2005;60:504-10.
20. Friedman M, Tanyeri H, La Rosa M, et al. Clinical predictors of obstructive sleep apnea. Laryngoscope 1999;109:1901-7.
21. Zonato AI, Bittencourt LR, Martinho FL, Junior JF, Gregorio LC, Tufik S. Association of systematic head and neck physical examination with severity of obstructive sleep apnea hypopnea syndrome. Laryngoscope 2003;113:973-80.
22. Robinson A, Guilleminault C. Obstructive Sleep Apnea Syndrome. In: Chokroverty S, ed. Sleep Disorders Medicine: Basic Science, Technical Considerations, and Clinical Aspects, 2nd ed. Boston: Butterworth-Heinemann; 1999.
23. Young T, Shahar E, Nieto FJ, et al. Predictors of sleep-disordered breathing in community-dwelling adults: the Sleep Heart Health Study. Arch Intern Med 2002;162:893-900.
24. Strohl KP, Redline S. Recognition of obstructive sleep apnea. Am J Respir Crit Care Med 1996;154:279-89.
25. Schellenberg JB, Maislin G, Schwab RJ. Physical findings and the risk for obstructive sleep apnea. The importance of oropharyngeal structures. Am J Respir Crit Care Med 2000;162:740-8.
26. Davies RJ, Ali NJ, Stradling JR. Neck circumference and other clinical features in the diagnosis of the obstructive sleep apnoea syndrome. Thorax 1992;47:101-5.
27. Flemons WW, Whitelaw WA, Brant R, Remmers JE. Likelihood ratios for a sleep apnea clinical prediction rule. Am J Respir Crit Care Med 1994;150:1279-85.
28. Johns MW. Reliability and factor analysis of the Epworth sleepiness

scale. Sleep 1992;15:376-81.
29. Chervin RD, Aldrich MS, Pickett R, Guilleminault C. Comparison of the results of the Epworth Sleepiness Scale and the Multiple Sleep Latency Test. J Psychosom Res 1997;42:145-55.
30. Sleep-related breathing disorders in adults: recommendations for syndrome definition and measurement techniques in clinical research. The Report of an American Academy of Sleep Medicine Task Force. Sleep 1999;22:667-89.
31. Hosmer DW Jr, Lemeshow S. Applied logistic regression. New York: John Wiley; 1989.
32. Metlay JP, Kapoor WN, Fine MJ. Does this patient have community-acquired pneumonia? Diagnosing pneumonia by history and physical examination. JAMA 1997;278:1440-5.
33. Heckerling PS, Tape TG, Wigton RS, et al. Clinical prediction rule for pulmonary infiltrates. Ann Intern Med 1990;113:664-70.
34. Solomon DH, Simel DL, Bates DW, Katz JN, Schaffer JL. The rational clinical examination. Does this patient have a torn meniscus or ligament of the knee? Value of the physical examination. JAMA 2001;286:1610-20.
35. Williams JW, Jr., Simel DL, Roberts L, Samsa GP. Clinical evaluation for sinusitis. Making the diagnosis by history and physical examination. Ann Intern Med 1992;117:705-10.
36. Naylor CD. The rational clinical examination. Physical examination of the liver. JAMA 1994;27:1859-65.
37. Rahaghi F, Basner RC. Delayed diagnosis of obstructive sleep apnea: don't ask, don't tell. Sleep Breath 1999;3:119-24.
38. Escourrou P, Luriau S, Rehel M, Nedelcoux H, Lanoe JL. Needs and costs of sleep monitoring. Stud Health Technol Inform 2000;78:69-85.
39. Flemons WW, Douglas NJ, Kuna ST, Rodenstein DO, Wheatley J. Access to diagnosis and treatment of patients with suspected sleep apnea. Am J Respir Crit Care Med 2004;169:668-72.
40. Pack AI. Sleep-disordered breathing: access is the issue. Am J Respir Crit Care Med 2004;169:666-7.