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ORIGINAL ARTICLE

Can CPAP be indicated in adult patients with suspected obstructive sleep apnea only on the basis of clinical data?

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Abstract
Background There is scarce information about whether the diagnosis of OSA supported only by medical record data can be a useful and reliable tool to initiate a CPAP treatment.
Objectives The aim of this study is to develop and assess the accuracy of clinical parameters for the diagnosis and prescription of CPAP in patients with suspected OSA.
Methods Adult patients who underwent polysomnography and completed the Berlin questionnaire, a clinical record, and the Epworth sleepiness scale were included in the study. A situation was simulated in which two blinded and independent observers would be able to indicate CPAP treatment if the patients were snorers with frequent apnea reports (≥3–4 times a week) and overweight (BMI>25 kg/m^2) plus one of the following: diurnal symptoms (tiredness after sleeping or at waking time ≥3–4 times a week or Epworth sleepiness scale >11), arterial hypertension, cerebrovascular accident, coronary event, type II diabetes or cardiac arrhythmias (observer 1, clinical criteria) or on the basis of the respiratory disturbance index, significant tiredness (≥3–4 times a week) or sleepiness (Epworth >11) and associated comorbidities (observer 2, reference method). The area under the ROC curve (ABC-ROC), sensitivity, specificity, and likelihood ratios were calculated.
Results Among 516 subjects (72 % men), the median age was 52 years, BMI 28.3 kg/m^2, and RDI 19.7 events/h. The ABC-ROC, sensitivity, specificity, and positive likelihood ratio of the clinical parameters were of 0.64 to 0.65, 31 to 33 %, 97 to 98 %, and 11 to15 respectively. No differences in the diagnostic performance of the clinical criteria were observed between men and women.
Conclusions These clinical parameters made it possible to indicate CPAP in approximately one third of the population with OSA which would have required it on the basis of their PSG and clinical history. This approach showed high specificity; hence, few patients who did not meet the criteria for CPAP use would have received this treatment.

Keywords Sleep apnea · Obstructive sleep apnea · Sleep questionnaire · Clinical decision · CPAP treatment

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Introduction

Obstructive sleep apnea (OSA) is a major health problem due to the significant morbidity and mortality reported in untreated patients with this condition in comparison with subjects who receive treatment with continuous positive airway pressure (CPAP) or patients without OSA [1, 2]. OSA affects from 2

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to 7.5 of the middle-aged general adult population [3]; this condition remains under-diagnosed in a high percentage of patients [4]. Currently, the diagnosis of OSA is based on clinical history data together with a demonstrated high respiratory disturbance index (RDI) in polysomnography (PSG) or respiratory polygraphy [5, 6]. However, the capacity for performing PSG or even respiratory polygraphy is limited. It has been estimated that 1155 sleep studies per 100,000 population per year would be required to adequately address the demand for diagnosis of patients with suspected moderate to severe OSA [4, 7]. Nevertheless, the necessary capacity would be higher if those patients who require a second sleep study to control the efficacy of a therapeutic intervention (mandibular advancement device, CPAP) or to evaluate the mildest forms of OSA were taken into consideration. This demand probably exceeds the present capacity to perform sleep studies in most countries. In addition, the apnea/hypopnea index derived from sleep studies correlates poorly with daytime sleepiness and neurocognitive impairment and does not reliably predict the clinical response to CPAP [8–10]. Therefore, simple strategies must be validated which allow for an accurate diagnosis and quick access to treatment, especially for the most severe forms of OSA. To diagnose OSA, numerous questionnaires and clinical prediction models have been developed that have demonstrated moderate sensitivity and specificity, which is the reason why they have been used to help patient selection for additional sleep studies [11, 12]. There is scarce information about whether the diagnosis of OSA supported only by medical record data can be a useful and reliable tool to initiate a CPAP treatment [13]. The validation of an instrument based on the clinical data would make it possible to reliably indicate CPAP in selected cases of patients with the most severe forms of OSA, in which the associated comorbidities and/or excessive sleepiness could increase cardiovascular morbimortality or traffic accidents. Therefore, the main objectives of this study were to develop and validate a clinical tool for diagnosing and prescribing a CPAP trial in patients with suspected OSA.

Methods

Patient selection

We examined the database comprising the period between 6 January 2012 and 10 January 2014 from the sleep laboratory of the Hospital Alemán. Adult patients over 18 years old who had undergone a polysomnography (PSG) and completed the Berlin questionnaire, a medical record, and the Epworth sleepiness scale (ESS) were preselected. The patients who did not respond to the Berlin questionnaire, those who reported not knowing whether they snored, or did not complete the ESS or the rest of the questionnaires or checked more than one option in any of the questions were excluded. In addition, subjects with suspected restless legs syndrome, narcolepsy, heart failure, cases referred for PSG and CPAP titration or those that had obtained a PSG with less than 180 min of total sleep time were not included for the analysis.

Measurements

All the patients enrolled in this study underwent a diagnostic PSG which included EEG (F4/A1, C4/A1, O2/A1), EOG (two channels), chin EMG, leg EMG (two channels), ECG, airflow by nasal pressure and an oral thermistor, thoracic and abdominal movements (two channels with piezoelectric sensors), snoring, SO_2 and body position. The polysomnographies were registered from 10:30–11:30 p.m. to 5:00–6:00 a.m. On the day of the study, the patients were given the following instructions: (1) to avoid napping and not to drink alcoholic or caffeinated beverages, (2) to continue taking the usual medication, (3) to eat supper between 8 and 9 p.m., and (4) to report to the sleep laboratory between 9 and 10:30 p.m. The PSG analysis was performed manually by two trained physicians following international criteria [14]. OSA was defined as an RDI ≥5. On arrival for the PSG, the patients completed a

Table 1 Criteria based on polysomnography and clinical history to indicate CPAP in patients with obstructive sleep apnea (observer 2)

1. Based on guidelines of the Sociedad Española de Neumonología y Cirugía Torácica (SEPAR)
Reference method (A)
1. RDI≥30 or
2. RDI≥5 and<30 plus one of the following:
(a) Frequent tiredness after sleeping (≥3–4 times a week)
(b) Frequent tiredness during waking time (≥3–4 times a week)
(c) Excessive daytime sleepiness (Epworth>11)
(d) Hypertension
(e) Coronary heart disease
(f) Ischemic or hemorrhagic stroke
(g) Diabetes type II
(h) Cardiac arrhythmias
2. Based on the guidelines of the AASM (American Academy of Sleep Medicine)
Reference method (B)
1. RDI≥15 or
2. RDI≥5 and <15 plus one of the following:
(a) Frequent tiredness after sleeping (≥3–4 times a week)
(b) Frequent tiredness during waking time (≥3–4 times a week)
(c) Excessive daytime sleepiness (Epworth>11)
(d) Hypertension
(e) Coronary heart disease
(f) Ischemic or hemorrhagic stroke
(g) Diabetes type II
(h) Cardiac arrhythmias

Spanish version of the ESS [15], the Berlin questionnaire [16], and a sleep medical record (see appendix). Body weight and height were recorded in all subjects while wearing only light clothes and no shoes. The Berlin questionnaire was translated into Spanish. This Spanish version of the Berlin questionnaire has been validated against polysomnography, and it has shown to have a sensitivity and specificity similar to that reported in the original literature [17, 18].

Study design and rationale

We simulated a situation where two blinded and independent observers could initiate treatment with CPAP. Observer 1 (ED) used only data from medical records to indicate treatment with CPAP, while observer 2 (CAN) utilized polysomnography and clinical data to decide CPAP therapy. Observer 2 (reference method) decided CPAP treatment on the basis of respiratory disturbance index (RDI) from polysomnography, significant daytime symptoms (tiredness after sleeping or during the day ≥3–4 times a week: questions 6 and 7 of the Berlin questionnaire or ESS higher than 11) and the presence or absence of comorbidities associated with OSA (hypertension, cardiac arrhythmias, coronary heart disease, ischemic or hemorrhagic stroke, and type 2 diabetes). Due to the different criteria published about which patients with OSA should be treated with CPAP, we established two reference methods based on the current guidelines [19, 20], in order to compare them with the clinical criteria which we have developed to diagnose OSA and prescribe CPAP. Since tiredness is a frequently reported symptom, it was included as a criterion to indicate CPAP in patients with OSA [21]. Accordingly, observer 2 decided to prescribe a CPAP trial in two different situations which were called reference methods A and B (Table 1).

The clinical criteria used by observer 1 to indicate a CPAP trial in patients with suspected OSA were based on previously published data and on a multiple logistic regression model developed to evaluate what clinical parameters were independent predictors of OSA. Adult OSA patients are typically overweight or obese and consult for snoring, apneas witnessed by another person and diurnal tiredness or sleepiness. Snoring results from the partial collapse of the pharynx which constitutes the central pathophysiological mechanism of OSA. This symptom is reported by most patients and has been shown to have a sensitivity higher than 90 %. The report of frequent apneas (≥3–4 times a week) is a symptom less often referred by patients but has a specificity of almost 90 %.

Table 2 Characteristics of the patients

	All	Female	Male	*p* value
Patient number	516	144	372	<0.001
Age (years)[a]	52 (39–61)	55 (42.5–63)	51 (39–61)	0.063
Body mass index (BMI) (kg/m^2)[a]	28.3 (25.2–31.9)	26.9 (23.4–33)	28.4 (26–31.4)	0.0057
Prevalence of OSA (%)	431 (83.5)	99 (68.7)	332 (89.2)	<0.001
Severity of OSA (%)				
RDI≥5 to <15	120 (23.2)	47 (32.6)	73 (19.6)	0.0025
RDI≥15 to <30	132 (25.6)	30 (20.8)	102 (27.4)	0.15
RDI≥30	179 (34.7)	22 (15.3)	157 (42.2)	<0.001
PSG				
Total recording time (TRT, min)[a]	402.1 (390–423)	400 (381–423)	402.1 (392–422)	0.8
Total sleep time (TST, min)[a]	341.3 (309.3–368)	332.8 (298–357)	346.7 (313–369.5)	0.0007
Total wakefulness time (TWT, min)[a]	55.5 (37.3–82.1)	64.6 (46.4–100.6)	53.5 (34.7–76.3)	0.0006
Sleep efficiency (SE)[a]	0.86 (0.80–0.90)	0.84 (0.75–0.88)	0.87 (0.81–0.91)	0.0003
TNREM (min)[a]	284.5 (256.5–309.3)	277.3 (251.1–304.8)	286 (258.7–309.3)	0.14
TREM (min)[a]	53.8 (37.3–70.4)	51.1 (32–66.9)	55.5 (40–72.8)	0.0288
Respiratory disturbance index (RDI)[a]	19.7 (8.2–37.7)	9 (2.8–21.9)	24.1 (12–42.8)	<0.001
Comorbidities				
Hypertension	175 (34)	45 (8.7)	130 (25.2)	0.001
Coronary heart disease	24 (4.6)	4 (0.8)	20 (3.8)	0.13
Ischemic or hemorrhagic stroke	11 (2.1)	0 (0)	11 (100)	<0.001
Cardiac arrhythmia	8 (1.5)	3 (0.6)	5 (0.9)	0.84
Diabetes type II	55 (10.7)	11 (2.1)	44 (8.6)	0.015

TNREM total stages 1+2+3+4, *TREM* total amount of REM sleep

[a] Data are presented as median (25–75 % percentiles) or *n* (%)

Table 3 Multiple logistic regression analysis relating a RDI≥5 (dependent variable) to the snoring, frequent apneas, BMI>25 kg/m^2, tiredness, and sleepiness (independent variables)

Independent variables	Coefficient	SE	OR	95 % CI	*p* value
Snoring	1.55	0.42	4.7	2–10.8	0.0003
Frequent apneas[a]	1.9	0.43	6.7	2.9–15.4	<0.0001
Overweight/obesity	1.57	0.28	4.8	2.8–8.3	<0.0001
Tiredness (after sleeping or at waking time) [a]	−0.44	0.29	0.64	0.36–1.14	0.13
Sleepiness (Epworth>11)	0.004	0.30	1	0.56–1.8	0.99

OR odds ratio, *SE* standard error, *95% CI* 95 % confidence interval

[a] ≥3-4 times a week

On the other hand, it has been observed that tiredness after sleeping or during the waking time and excessive daytime sleepiness had a sensitivity and specificity ranging between 47 and 58 % [22]. Kapuniai et al. [23] observed that the self-report of loud snoring and apneas during sleep made it possible to identify correctly 100 % of the subjects with an apnea/hypopnea index (AHI) higher than 40 and 76 % of patients with an AHI higher than 5. Based on the foregoing, we performed a multiple logistic regression analysis of our database to determine the relationship between the presence of OSA and the following independent variables: snoring, frequent apneas, overweight, frequent tiredness, and excessive diurnal somnolence. Then, the diagnostic accuracy of the combination of all the symptoms that independently predicted the presence of OSA was calculated. Finally, we hypothesized that those patients who had suggestive symptoms of OSA (i.e., the presence of all independent predictors of RDI ≥5) plus significant daytime symptoms (tiredness after sleeping or during the day ≥3–4 times a week or an ESS >11) or the presence of comorbidities could be candidates for CPAP therapy with a low probability that the physician made a mistake (i.e., indicated CPAP to a patient who did not meet the criteria according to reference method) (see "Results"). The self-report of comorbidities was considered a parameter to prescribe CPAP only in those patients who had been receiving any drug therapy for such conditions. An institutional review board approved the study protocol.

Statistical analysis

A frequency histogram and the Kolmogorov–Smirnov test were used to assess if the study variables had a normal distribution. Thus, when the distribution was normal, the mean and standard deviation were reported. Instead, if the distribution was not normal, the median and the percentiles 25–75 % were used. The sensitivity and specificity, area under the curve ROC (AUC-ROC), as well as the positive/negative likelihood ratio were calculated. A stepwise multiple logistic regression was performed to assess the association between the dependent variable RDI (RDI≥5=1, RDI<5=0) and the independent variables snoring (1=yes, 0=no), frequent apneas (≥3–4 times a week, 1=yes, 0=no), overweight (BMI>25 kg/m2, 1=yes, 0=no), frequent tiredness after sleeping or at waking time (≥3–4 times a week, 1=yes, 0=no), and excessive diurnal somnolence (ESS>11, 1=yes, 0=no). The Mann–Whitney or the chi-squared tests were used to compare the differences between the false negative versus true positive cases. The statistical analysis was carried out with a commercial computer program, MedCalc Statistical Software version 14 (MedCalc Software bvba, Ostend, Belgium; http://www.medcalc.org; 2014).

Results

Out of a total number of 688 patients initially preselected from the data base, 172 were excluded due to a variety of reasons (102 questionnaires were incomplete and/or patients had answered they did not know if they snored or had checked more than one option in any of the questions, 60 PSG were performed for CPAP titration and 10 PSG had had a total sleep time less than 180 min). Hence, 516 patients were included for the final analysis. In 19 cases, sleep architecture data were not available. The characteristics of the patients studied are shown in Table 2. The prevalence of OSA in our population was 83.5 % and 77 % were men. There was a predominance of patients with severe OSA in the study population (severe OSA 34.7 %, moderate and mild OSA 23.2 % and 25.6 %, respectively, $p<0.01$). Women had a lower RDI and body mass index as well as a higher frequency of mild forms of OSA in comparison with men.

The multiple logistic regression analysis of the most common symptoms in patients with OSA is shown in Table 3. The independent predictors of an RDI ≥5 were the report of snoring, frequent apneas, and the presence of overweight or obesity. Tiredness after sleep or at waking time and sleepiness

Table 4 Sensitivity and specificity of all independent predictors of OSA

Clinical characteristics	AUC-ROC (SE)	Sensitivity (95 % CI)	Specificity (95 % CI)
Snoring+frequent apneas+overweight	0.64 (0.016)	32.7 (28.3–37.4)	95.3 (88.4–98.7)

OSA=RDI ≥5

AUC-ROC area under the ROC curve, *SE* standard error, *95 % CI* 95 % confidence interval

Table 5 Clinical criteria used to diagnose obstructive sleep apnea and indicate CPAP (observer 1)

Snorers with overweight (BMI>25 kg/m^2) who reported the presence of frequent apnea (≥3-4 times a week) associated with any of the following conditions:
1. Frequent tiredness after sleeping (≥3–4 times a week)
2. Frequent tiredness during waking time (≥3–4 times a week)
3. Excessive daytime sleepiness (Epworth>11)
4. Hypertension
5. Coronary heart disease
6. Ischemic or hemorrhagic stroke
7. Diabetes type II
8. Cardiac arrhythmias

were not significantly associated with the presence of OSA. The area under the ROC curve (AUC-ROC), sensitivity and specificity of all symptoms which independently predicted those patients with obstructive sleep apnea are shown in Table 4. As it can be seen, the association of snoring, frequent apneas and overweight showed a low sensitivity but a high diagnostic specificity. The clinical criteria used by observer 1 to indicate CPAP therapy are shown in Table 5. Regardless of the reference method used, the clinical criteria showed a low sensitivity (31–33 %), a high specificity (97–98 %), and a positive likelihood ratio higher than 10 (Table 6). The diagnostic performance of the clinical criteria was similar in women and men (AUC-ROC women, 0.62; AUC-ROC men, from 0.62 to 0.66, $p>0.05$).

Based on the clinical criteria and reference method A, there were 125 true positive (TP), 256 false negative (FN), 132 true negative (TN) and three false-positive cases (FP). The TP cases had a body mass index and respiratory disturbance index higher than FN subjects. Also, they reported more frequently significant daytime sleepiness or tiredness. Most FN cases did not report frequent apneas (Table 7). The FP cases were three obese or overweight men with an RDI lower than 5 who reported snoring, frequent apneas, excessive daytime sleepiness and/or frequent daytime tiredness. None was taking sedative medication, nor had symptoms suggestive of restless leg syndrome or periodic leg movements in the PSG.

We estimated the costs and benefits of an approach based on the reference method A and clinical criteria to initiate a CPAP trial in our 516 patients cohort. For calculating this, we took into account the local market cost of a PSG, medical consultation, and an auto-CPAP trial. On the basis of these data, we could have saved US$25,000 (Table 8).

Discussion

The main finding of this simulated study was that in a cohort of subjects with high prevalence of OSA, we could diagnose OSA and indicate a CPAP treatment by using only simple clinical criteria in approximately one third of the population with OSA who in real life could have required it according to the PSG and their medical history. These theoretical clinical models to diagnose OSA and prescribe a CPAP trial had a sensitivity and specificity from 31 to 33 % and 97 to 98 %, respectively. The diagnostic performance of these clinical models was similar in men and women. This contrasts the data published by Rowley et al. [12], who observed that the diagnostic capacity of four clinical prediction models for OSA was higher in men than women. Possibly, the differences observed in comparison with our results are related to the fact that the formulas that they used included other parameters such as age, gender, body mass index, frequency or intensity of snoring, and neck circumference. In addition, our clinical parameters were developed to prescribe CPAP, so daytime symptoms or associated comorbidities are relevant variables for CPAP indication, a situation which was not taken into consideration in the clinical formulas used to diagnose OSA.

One of the drawbacks of our approach is that two thirds of the patients with OSA requiring CPAP would not have been identified because they did not meet the clinical parameters for treatment initiation with positive pressure (FN cases). This was mainly due to the fact that these patients did not report the presence of frequent apneas or reported fewer diurnal symptoms than the TP cases. This could be because, in part, the questionnaires were completed by the patients themselves. It has been reported that when the Berlin questionnaire (BQ) was completed by the bed partner, its sensitivity and specificity for diagnosing OSA (AHI> 15) was greater than when the BQ was self-reported. Also, self-reported snoring, choking or struggle for breath and sleepiness often tend to be underestimated compared with the same symptoms reported by third parties [24]. On the other hand, the questionnaire specificity was high, which constitutes an advantage

Table 6 Accuracy of clinical criteria to diagnose OSA and prescribe CPAP

Clinical criteria	AUC-ROC (SE)	Sensitivity (95 % CI)	Specificity (95 % CI)	LR+	LR−
CC vs. RM A	0.65 (0.014)	33 (28.3–38)	97.8 (83.7–99.5)	15.1 (4.9–46.5)	0.69 (0.6–0.7)
CC vs. RM B	0.64 (0.014)	31 (26.3–35.4)	97.2 (92.2–99.4)	11.1 (3.6–34.4	0.71 (0.7–0.8)

CC clinical criteria, *RM A or B* reference method A and B, *AUC-ROC* area under the ROC curve, *SE* standard error; positive and negative likelihood ratio, *95 % CI* 95 % confidence interval

Table 7 False-negative cases (clinical criteria versus reference method A)

	False negative	True positive	*p* value
Number	256	125	
Age (years)[a]	55 (46–63.5)	50 (38–60)	0.0012
BMI (kg/m^2)[a]	28.3 (25–31.7)	30.9 (28.4–34.8)	<0.001
RDI[a]	22 (13–38.5)	37 (21.7–60.4)	<0.001
Frequent apneas (≥3–4 times a week)	40 (15.6)	125 (100)	<0.001
Epworth>11	25 (9.8)	72 (57.6)	<0.001
Frequent tiredness (3–4 times a week)	165 (64.4)	107 (85.6)	<0.001
Comorbidities	119 (46.5)	65 (52)	0.4

[a] Values are expressed as median and interquartile range or *n* (%)

since it would avoid treatment initiation in most of the patients without the indication of CPAP. Using the clinical criteria and reference method A, observer 1 prescribed a CPAP trial unnecessarily to 2–3 % patients (FP cases). These patients reported frequent apneas despite the fact that the observed mean RDI was 2 and that they also showed a higher frequency of daytime symptoms than the patients who did not receive a CPAP indication. The dissociation between the report of frequent apneas and an RDI lower than 5 could be explained by the night-to-night variability of the RDI. It has been described that up to 25 % of the patients with a PSG revealing an AHI lower than 5 on one night can show an AHI between 5 and 30 on a second PSG [25]. Also, witnessed apnea may be reported in up to 6 % of the normal population [26]. In addition, a CPAP trial indication in subjects who did not require it could have only caused poor adherence or compliance or minor adverse effects without serious risks for the patient, a situation which could have also occurred in those patients who received a clear indication to use a positive pressure device. The availability of a diagnostic tool based on clinical data has a number of advantages. First, the very somnolent patients or with associated comorbidities who are at a higher risk of vascular events and traffic accidents could initiate a treatment with positive pressure sooner. Secondly, this strategy would clearly reduce costs since nearly one third of the patients would not require a sleep study for the initial diagnosis. Thirdly, the clinical criteria are very simple to implement and apply, which would allow primary care physicians or clinicians to indicate CPAP therapy initiation, especially when there is difficulty accessing diagnosis by means of a PSG or respiratory polygraphy.

Our results are similar to those in a recent publication in which two experts using a detailed clinical sleep history and complementary examinations could have reliably initiated CPAP in 52 % of the patients with suspected OSA who had been studied with a respiratory polygraphy. The level of agreement between both experts was good, but the rate of false-positive cases was high (11–26 %) [13]. Furthermore, the assessment of the clinical response to a 2-week CPAP trial in patients with a high probability of OSA has shown high diagnostic accuracy for diagnosing OSA and 3 % of false-positive cases [27]. Skomro et al. [28] showed that 91 % of patients selected for an empirical CPAP trial on the basis of

Table 8 Analysis of cost and benefits

	Number	Price per study[a]	Cost final	
Strategy based on PSG and clinical history				
1. PSG	516	200	103,200	
2. Auto-CPAP (one night)	381	50	19,050	
3. Medical consultation	516	20	10,320	
Total cost			132,570	
Strategy based on clinical criteria				
1. Medical consultation	516	20	10,320	
2. Auto-CPAP (one night)	125	50	6250	
3. Auto-CPAP (false-positive cases)	3	50	150	
4. PSG (negative clinical score)	391	200	78,200	
5. Auto-CPAP in false negative cases	256	50	12,800	
Total cost			107,720	
Cost saving				24,850

n number of studies

[a] Expressed as US dollars

high clinical suspicion of OSA had OSA by PSG testing. Most patients satisfactorily adhered to treatment and noted improvement in daytime somnolence.

Our study has a number of limitations. The first drawback of these theoretical models is that there is no agreement within the medical community about the OSA patients who should receive CPAP. The American Academy of Sleep Medicine recommends CPAP in patients with an RDI ≥15, or those with an RDI ≥5 and <15 together with excessive daytime sleepiness. On the other hand, Spanish guidelines recommend CPAP therapy for patients with an RDI ≥30, or when the RDI is between 5 and 30 in subjects with daytime sleepiness (Epworth>11) or related symptoms and/or comorbidities. Considering the fact that there is no universally accepted gold standard to indicate CPAP therapy in subjects with OSA, the prescription of positive airway pressure is left to the treating physician's discretion. This could obviously cause interobserver variations and, therefore, in the sensitivity and specificity results presented in this study. Secondly, we have included daytime tiredness within the symptoms to prescribe CPAP therapy. Despite the fact that daytime tiredness is a commonly reported symptom by patients, it is not clearly explicit in any current recommendations. The inclusion of this symptom in the theoretical models increased the number of subjects who required CPAP by approximately 30 %. Finally, to assess the accuracy of this strategy in real life, it would be necessary to carry out a randomized study involving several medical centers using the same gold standard in order that more valid conclusions can be drawn.

In conclusion, this simulated study has demonstrated that the use of a strategy based on a simple questionnaire made it possible to indicate CPAP in approximately one third of the population with OSA which would have required it according to the PSG and medical history. This approach showed high specificity, in such a way that less than 5 % of patients who met the clinical criteria for CPAP therapy would have received this treatment unnecessarily. This tool could be used to indicate empirically CPAP treatment in situations such as preoperative high-risk and/or in those subjects with suspected OSA who are very sleepy and/or have had traffic accidents or severe cardiovascular events.

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Comments:

The authors have done an excellent work in writing the manuscript entitled "Can CPAP be indicated in adult patients with suspected obstructive sleep apnea only on the basis of clinical data?". This is a very thought provoking and meticulous work and is a good pilot data for informing larger studies. The clinical question is relevant to our field and I have always thought about it.

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