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Indication of CPAP without a sleep study in patients with high pretest probability of obstructive sleep apnea

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Abstract

Objective To evaluate the performance of clinical criteria (CC) for diagnosis and initiation of empirical treatment with continuous positive airway pressure (CPAP) in patients with suspected obstructive sleep apnea (OSA) compared with the treatment decision based on sleep studies (polysomnography or respiratory polygraphy), guidelines, and experience of participating physicians.

Methods This was a simulated intention-to-treat study in a retrospective (G1) and prospective (G2) cohort. Four observers (two per group) called CC1 and CC2 reviewed the sleep questionnaires and indicated CPAP if the patients presented snoring, frequent apneas (≥ 3–4/week), body mass index (BMI) > 25 kg/m^2, sleepiness (Epworth > 11), or tiredness (at least 3–4 times per week) and some comorbidity (hypertension, coronary/cerebrovascular event, diabetes). Ten independent observers formed two groups of five (FD1 and FD2) and were blinded to each other's opinion. These observers in FD1 and FD2 decided CPAP treatment based on guidelines of the Spanish Society of Pulmonology and Thoracic Surgery (SEPAR) or guidelines of the American Academy of Sleep Medicine (AASM) and factored in their own opinion. Sensitivity (S), specificity (Sp), and positive/negative likelihood ratios (LR+/−) were calculated with the test method: CC1/2, and the reference method: majority decision of FD1/2.

Results A total of 653 patients (264 women, 40%) were studied. Median age was 54 years, BMI 28 kg/m^2, and apnea hypopnea index (AHI) 16.5 events/h. S ranged from 21 to 25% (p 0.60), Sp 96.1 to 97.6% (p 0.39), and LR+ of clinical criteria 6.4 to 8.9 (p 0.52).

Conclusion CPAP indication without a previous sleep study showed a low sensitivity (≅ 22%) but a specificity greater than 95% in patients with high pretest probability for OSA (snoring, report of frequent apneas, BMI > 25 kg/m^2 and sleepiness or tiredness plus comorbidity).

Keywords CPAP · Diagnosis · Sleep-disordered breathing · Obstructive sleep apnea · Clinical features

Introduction

Obstructive sleep apnea (OSA) affects approximately 20% of the general adult population [1]. It has been associated with high blood pressure, cardiovascular events, traffic accidents, and deteriorated quality of life (QoL) [2–4]. The best available treatment is positive continuous airway pressure (CPAP), which has been

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demonstrated to reduce excessive daytime sleepiness, traffic accidents rate, and blood pressure and improve QoL [5–9].

Current recommendations advise against the use of clinical tools, questionnaires, or prediction algorithms to diagnose OSA in the absence of polysomnography (PSG) or respiratory polygraphy (RP) due to their low accuracy to correctly classify patients in terms of apnea/hypopnea index (AHI) thresholds [10]. However, access to diagnosis for this prevalent disease is limited because the potential demand for sleep studies is greater than the offer from diagnostic centers [11, 12].

Considering that undiagnosed and untreated OSA has serious medical consequences that result in a significant economic burden [13], it is necessary to develop and validate simpler strategies that allow the physician to initiate CPAP therapy in more symptomatic patients with high clinical probability of suffering from severe forms of OSA who cannot promptly access a diagnostic test.

There is little information on whether or not the diagnosis of OSA based exclusively on clinical findings could be a sufficiently reliable tool to prescribe CPAP therapy in patients with high suspicion of OSA.

In two previous simulated intention-to-treat studies, CPAP indication based solely on clinical parameters showed low sensitivity (S) and high specificity (Sp) and positive likelihood ratio (LR+) compared with the decision made by observers who used a sleep study (PSG or RP) and the published guidelines [14, 15]. It is worth noting that the observers in these studies strictly followed current recommendations, without taking their experience into account.

Thus, based on the central role clinical judgment plays in routine practice, the primary objective of the present study was to evaluate the diagnostic accuracy of previously published clinical criteria for empirical indication of CPAP in patients with high clinical suspicion of OSA, compared with the decision for CPAP treatment based not only on the guidelines but also the judgment of the participating clinicians.

Material and methods

This was a simulated observational study conducted on two pre-existing databases that evaluated the intention-to-treat patients with suspected OSA with CPAP. An institutional ethics committee approved the research project.

Study procedure

Fourteen independent observers blinded to each other had to decide CPAP treatment in a retrospective (G1) and a prospective cohort (G2). Four of them (G1: CN, EB; G2: EB, IB) only analyzed the clinical criteria shown in Table 1, while the other ten observers relied on the clinical data (see Annex 1 and 2); the results of polysomnography (PSG) or respiratory polygraphy (RP), treatment guidelines; and their judgment (G1: CB, DV, SG, SM, HC; G2: CN, FN, EB, IB, ED).

Table 1 Clinical criteria to indicate CPAP in patients with suspected OSA

Snoring + BMI > 25 kg/m^2 + apnea (≥ 3–4 times a week) + Epworth > 11
Snoring + BMI > 25 kg/m^2 + apnea (≥ 3–4 times a week) + tiredness (≥ 3–4 times a week) + comorbidity (hypertension, coronary/ cerebrovascular event or diabetes type II).

BMI body mass index (kg/m^2)

The criteria for indicating CPAP by clinical parameters were supported in a previous publication [14]. The observers who only used clinical characteristics were called CC1 (G1) or CC2 (G2), while those who had access to sleep studies were identified as FD1 (G1) or FD2 (G2). FD1 followed the SEPAR (Sociedad Española de Neumología y Cirugía Torácica) guidelines [16], while FD2 used the AASM (American Academy of Sleep Medicine) recommendations [17] to indicate CPAP (see Table 2). The instruction given to FD1/2 for decision making was: "It is very important that you use your judgment and experience in each case to make your treatment decision. You should not apply the guidelines as a fixed rule."

Study population and patient selection

1. *Group 1 (G1)*

A database of 761 patients (304 women) on suspicion of OSA studied in the sleep laboratory of Hospital Alemán between 2013 and 2015 was used. An intentional sampling was carried out in order to have a similar proportion of men and women with an apnea/hypopnea index (AHI) less than 5 and with mild, moderate, and severe OSA. We included adult patients who had a PSG and filled in a standardized sleep questionnaire and excluded those with PSG with a total sleep time < 180 min or CPAP titration, oximetries with artifacts due to disconnections or displacement of the sensor in more than 5% of the total time of recording, subjects with clinical suspicion of narcolepsy or central apnea on PSG, incomplete sleep questionnaires, or questions with two answers.

2. *Group 2 (G2)*

Consecutive adult outpatients who consulted for suspicion of OSA at two community hospitals of the city of Buenos Aires (Hospital Alemán, Hospital Británico) between March and August of 2017 were studied. Informed consent, a sleep questionnaire, and a diagnostic RP or PSG were inclusion requirements. Exclusion criteria applied to patients with advanced oncological, psychiatric, neuromuscular, hepatic or

Table 2 Criteria to indicate CPAP based on SEPAR and AASM guidelines (FD1 and 2)

SEPAR	AASM
AHI ≥ 30 or AHI ≥ 5 and < 30 more one of the following:	AHI ≥ 15 or AHI ≥ 5 and < 15 more one of the following:
Epworth > 11	Epworth > 11
Frequent tiredness after sleeping (almost every day)	Frequent tiredness after sleeping (almost every day)
Frequent tiredness during waking time (almost every day)	Frequent tiredness during waking time (almost every day)
Hypertension	Hypertension
Coronary disease	Coronary disease
Ischemic or hemorrhagic stroke	Ischemic or hemorrhagic stroke
Diabetes type II	Diabetes type II

FD1/2 observers who based their decision on clinical data, guidelines, sleep study and experience, *SEPAR* Sociedad Española de Neumonología y Cirugía Torácica, *AASM* American Academy of Sleep Medicine, *AHI* apnea/hypopnea index

renal diseases, heart failure, valid total recording time < 240 min in RP, total sleep time less than 180 min in PSG, use of oxygen or non-invasive ventilation, and diagnosis or previous treatment for OSA.

All the information relevant for decision making was available either on a website, which could be accessed by each researcher with an individual username and password (G1), or an Excel database (G2).

Figures 1 and 2 show the flow diagrams for the selection of patients.

Measurements and definitions

All the patients had a diagnostic sleep study. G1 underwent PSG, while G2, according to the availability or medical criteria, had PSG or RP. PSGs were carried out with computerized equipment Mini PC (Akonic SA) or PDX (Philips, Respironics). The variables recorded were electroencephalography (EEG: F3/4, C3/4, O1/2), electromyography (EMG chin, legs), electrooculography (EOG), electrocardiography (ECG), airflow (nasal pressure and thermistors), thoracic/abdominal bands, oxygen saturation (SO_2), and body position. RP was made with ApneaLink Plus devices (AL, Resmed) that patients self-placed at home [18]. AL measures airflow and snoring by nasal pressure, respiratory effort through a thoracic band and SO_2 and heart rate by pulse oximetry. Sleep studies with a valid total recording time < 4 h or artifices in any of the signals were repeated. PSGs were read manually, and AL analysis was automatic (software version 10) with subsequent manual correction. OSA was defined as an AHI ≥ 5.

International criteria were used for the analysis of signals, sleep staging, and classification of OSA severity [19].

On the night of PSG in the sleep laboratory (G1) or during the first visit to the office (G2), patients completed a standardized sleep questionnaire (see Annexes 1 and 2). Comorbidities were considered when patients reported them in the questionnaire and/or if they received medication for that condition. Excessive daytime sleepiness was defined as an Epworth Sleepiness Scale (ESS) > 11. Restless legs syndrome was diagnosed when patients complained of uncomfortable sensations in the legs before sleeping and reported behaviors to relieve these discomforts (rubbing or moving the legs, getting up, and walking).

Statistical analysis

Depending on the distribution of the variables, the values were reported as mean and standard deviation or median and 25–75% percentiles. S, Sp, and LR +/− of clinical criteria (test method) were calculated (Table 1). The reference method (RM) for the indication of CPAP was the decision most frequently taken by the FD1/2 (mode), who relied on SEPAR (G1) and AASM (G2) guidelines and their personal criteria. Chi-square or Mann-Whitney test was used to compare true- and false-positive (TP/FP) patients. A commercially available

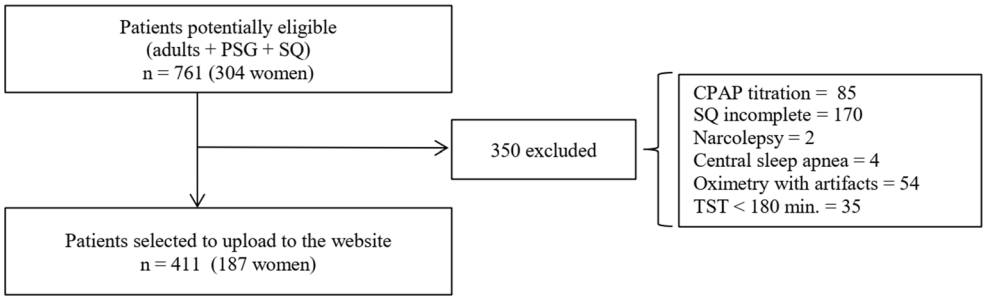

Fig. 1 Flow chart for patient selection of group 1-G1 (PSG polysomnography, SQ sleep questionnaires, TST total sleep time)

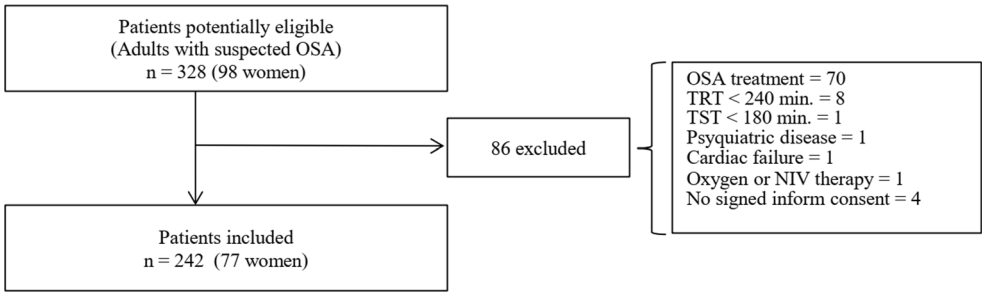

Fig. 2 Flow chart for patient selection of group 2-G2 (OSA obstructive sleep apnea, TRT total recording time, TST total sleep time, NIV non-invasive ventilation)

program for data analysis was used (MedCalc Software, Version 18.11.6, Mariakerke, Belgium).

Results

In G1, of 761 initially preselected patients, 350 were excluded for several reasons (see Fig. 1), so that 411 subjects remained for analysis. The characteristics of G1 are presented in Table 3. The median age was 54 years; there were 45.5% (187) of women, 76.4% (314) had OSA, and 31.4% (129) were obese. A similar percentage of subjects without (23.6%) and with mild (23.8%), moderate (25.6%), and severe (27%) OSA (p 0.8) was observed. ESS greater than 11 was present in 31.9% of subjects and 43.5% of the patients had at least one comorbidity (hypertension, coronary/cerebrovascular event or type II diabetes).

In G2, out of a total of 328 consecutive patients, 98 were excluded for different reasons (see Fig. 2). The final sample consisted of 242 patients (32% women) with a median age, BMI, and AHI of 51 years, 29.8 kg/m^2, and 15, respectively. The prevalence of OSA was 81% and the proportion of mild, moderate, and severe forms was similar (31%, 24.8%, and 25.6%, p 0.46). A total of 24.4% of the patients had sleepiness. The other characteristics of the study population are shown in Table 4.

The diagnostic accuracy of the clinical criteria for prescribing CPAP is presented in Table 5. S, Sp, and LR+ were similar in both groups (S/Sp/LR+ in G1 and G2: 21/24.8%, 97.6/96.1%, 8.9/6.4, p 0.6, 0.39, and 0.52). S, Sp, and LR+ averages in both groups were 22.4% (CI95% 17.9–27.4), 97.1% (CI95% 94.7–98.6), and 7.6 (CI95% 4–14.5), respectively. The performance of the symptoms to indicate empirically CPAP in women and men was similar (S: 23.4/21.8%, p 0.75; Sp: 98.1/96.2%, p 0.30).

In G1 and G2, TP cases (70) were patients with moderate to severe OSA compared to FP subjects. TP cases presented AHI, ODI3, T90 median of 36.7, 31.3, and 16.3. FP (10) showed AHI, ODI3, T90 median of 4.9, 4.5, and 0.3, $p <$ 0.01). Symptoms such as sleepiness, tiredness, or comorbidities were similar in both groups (see Table 6). Table 7 compares the true (TN) and false negative (FN) cases. There were 243 FN cases. FN had a median AHI, ODI3, and T90 of 30.7 (22–43), 24 (16–36), and 11 (3.9–25.5).

CPAP indication based strictly on the SEPAR or AASM recommendations was on average 66% (G1: 265/411, 64.5%; G2: 167/242, 69%) while FD1/2 suggested positive pressure in 48% of the cases (G1: 200/411, 48.7%, G2: 113/242, 46.7%) ($p < 0.01$).

Table 3 Characteristics of group 1 (G1)

Patient number	411
Female	187 (45.5)
Age (years)	54 (42–64)
Body mass index (BMI kg/m^2)	27.8 (24.7–31.2)
Prevalence of OSA (AHI ≥ 5)	314 (76.4)
Epworth > 11	131 (31.9)
Comorbidities	179 (43.5)
- Hypertension	135 (32.9)
- Coronary heart disease	22 (5.35)
- Ischemic or hemorrhagic stroke	9 (2.2)
- Diabetes type II	101 (24.6)
Restless leg syndrome	107 (24.6)
Polysomnography	
- TRT (total recording time, min)	395.5 (383.5–420))
- TST (total sleep time, min)	334.4 (298.7–362.7)
- SE (sleep efficiency)	85 (79–90)
- TNREM (min)	277.3 (249.9–302.4)
- TREM (min)	53 (37.3–69.3)
- AHI (Apnea/Hypopnea Index)	16.5 (6.2–32)
- T90 (%)	2.2 (0.2–12.1)
- ODI3	9.6 (3.8–20.8)
Severity of OSA (%)	
- AHI ≥ 5–< 15	98 (23.8)
- AHI ≥ 15–< 30	105 (25.6)
- AHI ≥ 30	111 (27)

Data are presented as median (25–75% percentiles), or n (%)

TNREM total stages N1 + N2 + N3, *TREM* total amount of REM sleep, *ODI3* oxygen desaturation index ≥ 3%, *T90 (%)* percentage of TRT at SO2 < 90%

Table 4 Characteristics of group 2 (G2)

Patient number	242
Female	77 (38.2)
Age (years)	51 (41–61)
Body mass index (BMI kg/m^2)	29.7 (26–34.6)
Prevalence of OSA (AHI ≥ 5)	197 (81.4)
Epworth > 11	59 (24.4)
Comorbidities	104 (43)
- Hypertension	69 (28.5)
- Coronary heart disease	29 (12)
- Ischemic or hemorrhagic stroke	8 (3.3)
- Diabetes type II	49 (20.2)
Restless leg syndrome	57 (23.6)
Polysomnography (n = 21)	
- TRT (total recording time, min)	407 (390.2–425.7))
- TST (total sleep time, min)	364 (288–399.2)
- SE (sleep efficiency)	89 (78–96)
- TNREM (min)	286 (242.6–339.9)
- TREM (min)	59 (46.6–75.3)
- AHI (Apnea/Hypopnea Index)	24 (16.5–38.5)
- T90 (%)	3.1 (0.7–13.7)
- ODI3	19.5 (9.7–26.7)
Respiratory polygraphy (n = 221)	
- VET (valid evaluation time, min.)	387 (344–438)
- AHI (Apnea/Hypopnea Index)	13.4 (5.9–27.6)
- T90 (%)	5 (1–19)
- ODI3	15 (6.7–27.3)
Severity of OSA (%)	
- AHI ≥ 5–< 15	75 (31)
- AHI ≥ 15–< 30	60 (24.8)
- AHI ≥ 30	62 (25.6)

Data are presented as median (25–75 % percentiles), or n (%)

TNREM total stages N1 + N2 + N3, *TREM* total amount of REM sleep, *ODI3* oxygen desaturation index ≥ 3%, *T90 (%)* percentage of TRT or VET at SO2 < 90%

Discussion

The most relevant finding of this study was that the application of a simple questionnaire and the clinical criteria presented in Table 1 allowed to indicate CPAP with low chance of error (FP < 5%) to 20% of the patients with suspected OSA. These patients finally required positive pressure according to the sleep study and experience of sleep-disordered breathing specialists.

When it comes to confirming a diagnosis, it is important to have a test with high Sp to reduce the risk of considering a healthy subject sick (FP), and therefore indicate a treatment to a patient who does not need it. Although the presence of snoring reported apneas at least 3–4 times per week, a BMI > 25 kg/m^2 associated with symptoms and/or comorbidities in some of the combinations shown in Table 1 had low S, the Sp was > 95% in both study populations (G1, G2), so that only a small proportion of patients would have had an unnecessary CPAP trial.

There were 10 FP cases (G1, G2), of whom five were mild OSA with an ESS > 11 or presented tiredness and at least one comorbidity. These patients were candidates for CPAP according to the AASM guidelines but FD1/2 did not opt for positive pressure. The other five FP subjects did not have OSA but met some of the clinical criteria for CPAP therapy. The discrepancy between the report of frequent apneas and the sleep study could be explained by the fact that up to 25% of patients with an AHI < 5 in the first PSG can have mild to moderate OSA in a second study [20].

Out of the 80 patients who met some of the clinical criteria to start CPAP treatment, 75 had OSA (94%), of whom 68 (85%) had an AHI of ≥ 15. On the other hand, in terms of clinical criteria, the LR+ was 7 on average, which means that the post-test probability of a subject having an indication for CPAP increased from 49% (subjects who had CPAP indication according to the reference method) to almost 90% [21].

The FD1/2 indicated 93 fewer CPAP tests than observers who exclusively based their decision on the guidelines (339 vs. 432), which implies that they relied on their experience and judgment in the decision-making process.

These observations are similar to those previously published. The use of clinical data [14] or the STOP BANG questionnaire [15] enable researchers to indicate CPAP in approximately one third of the population with moderate to high pretest probability for OSA. In these studies, two independent blind observers (O1, O2) based their CPAP treatment decisions on clinical parameters (O1) or on the symptoms and results of PSG or RP (O2). In the previous studies, O2 strictly applied SEPAR or AASM guidelines, leaving aside their expertise or opinion. The observers in the present study based their decision not only on the guides but also their experience

Table 5 Diagnostic accuracy of clinical criteria to indicate CPAP

Group	Sensitivity (CI95%)	Specificity (CI95%)	LR+ (CI95%)	LR− (CI95%)
G1	21 (15.6–27.3)	97.6 (94.6–99.2)	8.9 (3.6–21.9)	0.81 (0.8–0.9)
G2	24.8 (17.1–33.8)	96.1 (91.2–98.7)	6.4 (2.6–16)	0.78 (0.7–0.9)
Pooled (G1+G2)	22.4 (17.9–27.4)	97.1 (94.7–98.6)	7.6 (4–14.5)	0.8 (0.8–0.9)

CI95% confidence interval 95%, *LR+/LR−* positive and negative likelihood ratio

Table 6 True and false positive cases (G1 plus G2)

Variable	TP (n = 70)	FP (n = 10)	p value
BMI (kg/m^2)	32 (28.8–36.2)	29.1 (28–37.3)	0.34
AHI	36.7 (24–53)	4.9 (2.2–7.3)	< 0.001
- AHI < 5	0	5 (50)	< 0.001
- AHI ≥ 5–< 15	4 (6)	5 (50)	< 0.001
- AHI ≥ 15–< 30	22 (31)	0	< 0.05
- AHI ≥ 30	44 (63)	0	< 0.01
ODI3	31.3 (20–48)	4.5 (2.2–6.7)	< 0.001
T90 (%)	16.3 (5.6–32.8)	0.3 (0–1)	< 0.001
Epworth	14 (11–16)	11.5 (8–14)	0.12
Epworth > 11	51 (73)	5 (50)	0.14
Tiredness (≥ 3–4 times a week)	61 (87)	9 (90)	0.79
Comorbidities (at least one)	46 (66)	7 (70)	0.80

Data are presented as median (25–75% percentiles), or n (%)

BMI body mass index (kg/m^2), *AHI* apnea/hypopnea index, *ODI3* oxygen desaturation index ≥ 3%, *T90 (%)* percentage of TRT (total recording time) or VET (valid evaluation time) at SO2 < 90%

since, in routine practice, the physician cannot always apply CPAP treatment guidelines due to different constraints.

In line with these observations, clinical improvement after a 14-day CPAP trial and treatment compliance have been used as diagnostic tools in patients with high probability of OSA and have demonstrated a low rate of false positives [22, 23].

One of the main strengths of this study is the fact that S and Sp values of the clinical criteria for empirically indicating CPAP were reproducible in both cohorts of patients despite using two different diagnostic methods (PSG or RP). In addition, there were several observers who decided to treat a significant sample of subjects with CPAP based exclusively on the different guidelines and their judgment.

The main drawback of this study was that the sensitivity of the clinical criteria to indicate CPAP was low. This is probably due in part to the fact that only 24% of patients reported apneas witnessed by someone at least 3 or 4 times per week. Thus, a large number of patients who were candidates for positive pressure according to AHI and medical history failed to meet all symptoms for an empirical CPAP trial. Thus, those patients who did not have the clinical criteria should be evaluated with a sleep study to avoid excluding patients who should receive treatment with CPAP. In addition, this is a simulated intention-to-treat study, and therefore, it is necessary to conduct a multicenter real-life clinical trial to prove if the application of these clinical criteria produces similar results. It is also worth noting that, due to the design of the study, the observers who used all the available information did not take into account the preferences of the patients for decision making, which could have changed the medical indication. Finally, the participants in this

Table 7 True and false negative cases (G1 plus G2)

Variable	TN (n = 330)	FN (n = 243)	p value
BMI (kg/m^2)	26.3 (24–29.5)	30.1 (27–34.5)	< 0.001
AHI	6.8 (2.4–11.6)	30.7 (22–43)	< 0.001
- AHI < 5	137 (41.5)	0	< 0.001
- AHI ≥ 5–< 15	152 (46)	12 (5)	< 0.001
- AHI ≥ 15–< 30	41 (12.4)	102 (42)	< 0.001
- AHI ≥ 30	0	129 (53)	< 0.001
ODI3	5 (2.4–9)	24 (16–36)	< 0.001
T90 (%)	0.4 (0–3)	11 (3.9–25.5)	< 0.001
Epworth	7 (4–11)	8 (5–12)	0.01
Epworth > 11	73 (22)	61 (25)	0.4
Tiredness (≥ 3–4 times a week)	197 (60)	145 (60)	1
Comorbidities (at least one)	100 (30)	130 (53.5)	< 0.001

Data are presented as median (25–75 % percentiles), or n (%)

BMI body mass index (kg/m^2), *AHI* apnea/hypopnea index, *ODI3* oxygen desaturation index ≥ 3%, *T90 (%)* percentage of TRT (total recording time) or VET (valid evaluation time) at SO2 < 90%

study were experienced physicians in the management of sleep-related breathing disorders, so its applicability in primary care would require a clinical trial in this context.

Our observations have clinical relevance since patients suspected of OSA with tiredness and vascular comorbidities or sleepiness, who for some reason have delays or inaccessibility to diagnostic tests, could initiate empirical treatment with CPAP safely with little chance of error. In addition, this diagnostic clinical strategy could potentially reduce health costs, since it would avoid carrying out a sleep study in 20% of patients who consult for suspicion of OSA.

In conclusion, this simulated study of empirical intention to treat with CPAP has shown that, in patients with high pretest probability for OSA (snoring, frequent apneas, BMI > 25 kg/m^2 and drowsiness or fatigue plus some comorbidity), sleep-disordered breathing specialists could safely and reliably indicate a CPAP trial in one out of five patients with suspected OSA without a previous sleep study.

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Author contributions Study design: CAN, EB; data collection: MB, EB, ED, CB, SM, SG, IB; statistical analysis: CAN, GE; data interpretation: CAN, FN, EB, ED; manuscript preparation: CAN, FN, EB, LL, AC, CE, MV, CB; literature search: ED, MV, SM.

Compliance with ethical standards

Conflict of Interest The authors declare that they have no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of our institutional committee and with the 1964 Helsinki declaration and its later amendments.

References

1. Franklin KA, Lindberg E (2015) Obstructive sleep apnea is a common disorder in the population-a review on the epidemiology of sleep apnea. J Thorac Dis 7(8):1311–1322
2. Kendzerska T, Mollayeva T, Gershon AS, Leung RS, Hawker G, Tomlinson G (2014) Untreated obstructive sleep apnea and the risk for serious long-term adverse outcomes: a systematic review. Sleep Med Rev 18(1):49–59
3. Teran-Santos J, Jimenez-Gomez A, Cordero-Guevara J (1999) The association between sleep apnea and the risk of traffic accidents. Cooperative Group Burgos-Santander. N Engl J Med 340(11):847–851
4. Bjornsdottir E, Keenan BT, Eysteinsdottir B, Arnardottir ES, Janson C, Gislason T, Sigurdsson JF, Kuna ST, Pack AI, Benediktsdottir B (2015) Quality of life among untreated sleep apnea patients compared with the general population and changes after treatment with positive airway pressure. J Sleep Res 24(3):328–838
5. Jenkinson C, Davies RJ, Mullins R, Stradling JR (1999) Comparison of therapeutic and sub-therapeutic nasal continuous positive airway pressure for obstructive sleep apnoea: a randomised prospective parallel trial. Lancet 353(9170):2100–2105
6. Batool-Anwar S, Goodwin JL, Kushida CA, Walsh JA, Simon RD, Nichols DA, Quan SF (2016) Impact of continuous positive airway pressure (CPAP) on quality of life in patients with obstructive sleep apnea (OSA). Sleep Res 25(6):731–738
7. Karimi M, Hedner J, Häbel H, Nerman O, Grote L (2015) Sleep apnea-related risk of motor vehicle accidents is reduced by continuous positive airway pressure: Swedish Traffic Accident Registry data. Sleep 38(3):341–349
8. Fava C, Dorigoni S, Dalle Vedove F, Danese E, Montagnana M, Guidi GC, Narkiewicz K, Minuz P (2014) Effect of CPAP on blood pressure in patients with OSA/hypopnea a systematic review and meta-analysis. Chest 145(4):762–771
9. Kuhn E, Schwarz EI, Bratton DJ, Rossi VA, Kohler M (2017) Effects of CPAP and mandibular advancement devices on health-related quality of life in OSA: a systematic review and meta-analysis. Chest 151(4):786–794
10. Kapur VK, Auckley DH, Chowdhuri S, Kuhlmann DC, Mehra R, Ramar K, Harrod CG (2017) Clinical practice guideline for diagnostic testing for adult obstructive sleep apnea: an American Academy of Sleep Medicine Clinical Practice Guideline. J Clin Sleep Med 13(3):479–504
11. Young T, Evans L, Finn L, Palta M (1997) Estimation of the clinically diagnosed proportion of sleep apnea syndrome in middle aged men and women. Sleep 20(9):705–706
12. Flemons WW, Douglas NJ, Kuna ST, Rodenstein DO, Wheatley J (2004) Access to diagnosis and treatment of patients with suspected sleep apnea. Am J Respir Crit Care Med 169(6):668–672
13. Knauert M, Naik S, Gillespie MB, Kryger M (2015) Clinical consequences and economic costs of untreated obstructive sleep apnea syndrome. World J Otorhinolaryngol Head Neck Surg 1(1):17–27
14. Nigro CA, Dibur E, Aragone MR, Borsini E, Ernst G, Nogueria F (2016) Can CPAP be indicated in adult patients with suspected obstructive sleep apnea only on the basis of clinical data? Sleep Breath 20(1):175–182
15. Borsini EE, Blanco M, Ernst G, Montenegro P, Salvado A, Nigro C (2018) Simulated intention-to-treat analysis based on clinical parameters of patients at high risk for sleep apnea derivated to respiratory polygraphy. Sleep Sci 11(3):160–165
16. Lloberes P, Durán-Cantolla J, Martínez-García MÁ, Marín JM, Ferrer A, Corral J, Masa JF, Parra O, Alonso-Álvarez ML, Terán-Santos J (2011) Diagnosis and treatment of sleep apnea-hypopnea syndrome. Spanish Society of Pulmonology and Thoracic Surgery. Arch Bronconeumol 47(3):143–156
17. Kushida CA, Littner MR, Hirshkowitz M, Morgenthaler TI, Alessi CA, Bailey D, Boehlecke B, Brown TM, Coleman J Jr, Friedman L, Kapen S, Kapur VK, Kramer M, Lee-Chiong T, Owens J, Pancer JP, Swick TJ, Wise MS (2006) American Academy of Sleep Medicine. Practice parameters for the use of continuous and bilevel positive airway pressure devices to treat adult patients with sleep related breathing disorders. Sleep 29(3):375–380
18. Borsini E, Maldonado L, Décima T, Bosio M, Quadrelli S, Chertcoff J, Salvado A (2013) Estrategia de utilización domiciliaria de la poligrafía respiratoria con instalación por el propio paciente. Rev Arg Med Resp 13(1):4–11
19. Berry RB, Budhiraja R, Gottlieb DJ, Gozal D, Iber C, Kapur VK, Marcus CL, Mehra R, Parthasarathy S, Quan SF, Redline S, Strohl KP, Ward SLD, Tangredi MM (2012) Rules for scoring respiratory events in sleep: update of the 2007 AASM Manual for the Scoring of Sleep and Associated Events. J Clin Sleep Med 8(5):597–619
20. Le Bon O, Hoffmann G, Tecco J, Staner L, Noseda A, Pelc I, Linkowski P (2000) Mild to moderate sleep respiratory events: one negative night may not be enough. Chest 118(2):353–359

21. Fagan TJ (1975) Nomogram for Bayes theorem. N Engl J Med 293(5):257
22. Senn O, Brack T, Russi EW, Bloch KE (2006) A continuous positive airway pressure trial as a novel approach to the diagnosis of the obstructive sleep apnea syndrome. Chest 129(1):67–75
23. Skomro RP, Cotton DJ, Gjevre JA, Grover VK, McNab BD, Reid JK, Ward HA (2007) An empirical continuous positive airway pressure trial for suspected obstructive sleep apnea. Can Respir J 14(3):159–163