ORIGINAL ARTICLES

Comparison Between the 1993 and 2002 Guidelines of the Spanish Society of Pulmonology and Thoracic Surgery (SEPAR) for Identifying Respiratory Events in Polysomnography Tests

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OBJECTIVE: To compare the results of applying both the 1993 and 2002 guidelines of the Spanish Society of Pulmonology and Thoracic Surgery (SEPAR) to identify respiratory events during nighttime polysomnography tests.

PATIENTS AND METHODS: One hundred twenty consecutive patients with medium to high suspicion of sleep apnea-hypopnea syndrome (SAHS) were included in the study. The 1993 guidelines recommended the use of a thermistor and the evaluation of only apneas and hypopneas. The 2002 guidelines, on the other hand, recommended the use of a thermistor, nasal pressure cannula, and thoracoabdominal bands so that respiratory effort related to arousals could be studied along with apneas and hypopneas.

In our study we did not use an esophageal pressure catheter. We calculated the apnea index, hypopnea index, and apnea-hypopnea index (AHI) and determined the number of patients who would be diagnosed with SAHS (AHI ≥10) and the number for whom initiation of continuous positive airway pressure treatment would be recommended (AHI ≥30) according to the 2 sets of guidelines.

RESULTS: Polysomnographic tests were valid for 118 of the 120 patients (80% men). The mean (SD) age was 51 (11.6) years and the mean body mass index 31.2 (4.3). Using the 1993 guidelines, the AHI was less than 10 in 25 patients, between 20 and 29 in 38, and 30 or more in 50. In the group overall, mean apnea and hypopnea indices and AHI were all significantly higher with the 2002 guidelines than with the 1993 criteria. With the 1993 criteria, the mean AHI was 33.16 and with 2002 criteria, 45.02 (*P*<.05). Sixty-four percent of the studies considered normal according to the 1993 SEPAR guidelines were considered apneic according to the 2002 guidelines. Of the patients considered not to need continuous positive airway pressure according to the 1993 SEPAR guidelines, 47.61% did need therapy according to the 2002 guidelines.

CONCLUSIONS: There are significant differences in AHI, and in both apnea and hypopnea indices depending on whether the 1993 or the 2002 SEPAR guidelines are applied.

Key words: *Sleep apnea. Nasal pressure cannula. Respiratory events.*

Comparación entre las normativas de la SEPAR de 1993 y 2002 en la lectura de los eventos respiratorios de las mismas polisomnografías

OBJETIVO: Comparar las normativas de la Sociedad Española de Neumología y Cirugía Torácica (SEPAR) de 1993 y 2002 mediante la lectura de los eventos respiratorios de las mismas polisomnografías nocturnas.

PACIENTES Y MÉTODOS: Se ha incluido en el estudio a 120 pacientes consecutivos con sospecha media-alta de síndrome de apneas-hipopneas (SAHS) durante el sueño. En la normativa de 1993 se usaba el termistor y sólo se valoraban las apneas y las hipopneas, mientras que en la de 2002 se emplean el termistor, la cánula de presión nasal y las bandas toracoabdominales, y se contabilizan aquéllas y los esfuerzos respiratorios relacionados con el despertar transitorio.

En nuestro estudio no se utilizó la sonda de presión esofágica. Se dedujeron los índices de apneas, hipopneas y apneas-hipopneas (IAH). Se determinó a cuántos pacientes se diagnosticaba de SAHS (IAH ≥ 10) y cuántos eran subsidiarios de tratamiento con presión positiva continua de la vía respiratoria (IAH ≥ 30) al aplicar las 2 normativas.

RESULTADOS: Fueron válidos 118 estudios. El 80% correspondía a varones y el 20% a mujeres. La edad media (± desviación estándar) de los pacientes era de 51 ± 11,6 años, y el índice de masa corporal medio de 31,2 ± 4,3. Con la normativa de 1993, 25 pacientes tenían un IAH < 10; 38 entre 10 y 29, y dicho índice era ≥ 30 en 50 sujetos. En el grupo total, el IAH, el índice de apneas y el de hipopneas fueron significativamente mayores con los criterios de 2002. El IAH medio de 1993 era de 33,16, y el de 2002 fue de 45,02 (p < 0,05). El 64% de los estudios normales con la normativa SEPAR de 1993 se consideraron apneicos con la de 2002. El 47,61% de los pacientes no tratables con presión positiva continua de la vía respiratoria según la normativa SEPAR de 1993 pasó a serlo con la de 2002.

CONCLUSIONES: Existen notables diferencias en el IAH, índice de apneas e índice de hipopneas según se aplique la normativa de la SEPAR de 1993 o la de 2002.

Palabras clave: *Apnea del sueño. Cánula de presión nasal. Eventos respiratorios.*

Introduction

Sleep apnea-hypopnea syndrome (SAHS) is characterized by episodes of total obstruction (apnea) or partial obstruction (hypopnea) of the upper airways during sleep that cause oxygen desaturations and arousals leading to fragmented nonrestorative sleep. The Spanish Society of Pulmonology and Thoracic Surgery (SEPAR) published guidelines in 1993[1] to standardize the counting of respiratory events (apneas and hypopneas) based on the use of a thermistor or thermocouple. On the basis of these guidelines, an apnea-hypopnea index (AHI) of 10 was established as the cutoff point indicative of SAHS[2] and an AHI of 30 accompanied by daytime symptoms and relevant risk factors as the cutoff point for initiation of nasal continuous positive airway pressure (CPAP).[3]

Later the use of a nasal pressure cannula[4-6] and, to a lesser extent, that of esophageal pressure catheters[7] became widespread, thereby increasing the accuracy of respiratory event detection, and another respiratory event known as a respiratory effort-related arousal (RERA) was described.[8] In response to these new developments, SEPAR published new guidelines in 2002,[9] in which the cutoff points for the diagnosis and treatment of SAHS with CPAP remained unchanged.

The objective of the present study was to compare the results of applying the 1993 and 2002 guidelines in identifying respiratory events in the polysomnography tests of a group of patients.

Patients and Methods

In the study we included 120 consecutive patients with medium to high suspicion of SAHS who had come for nighttime polysomnography to be carried out in a hospital with a specific unit for sleep-disturbed breathing between January 2000 and March 2001.

Sleep Studies

The polysomnography tests were carried out with 2 Alice 3 (Healthdyne Technologies, Marietta, Georgia, USA) polysomnographs with 18 channels: 2 for electroencephalographic recording (C_3A_2 and C_4A_1), 2 for eye movements, 1 for oronasal airflow measured by a thermistor (Healthdyne Technologies, Marietta, Georgia, USA), 1 for snoring, 1 for a nasal pressure cannula (Allegiance Healthcare Corporation, McGaw Park, Illinois, USA) connected to a model PTAF2 pressure transducer (Pro-Tech Inc, Woodinville, Washington, USA), 1 for the thoracic band, 1 for the abdominal band (both bands of the piezoelectric type), 1 for submental muscular activity, 2 for leg movement, 2 for the continuous electrocardiogram recording, 2 for oxygen saturation, 1 for the altimeter, and 1 for body position.

Respiratory Events

Respiratory events were counted in 2 different ways:

1. For one analysis, we applied the 1993 SEPAR guidelines, in which apnea is considered to be the absence of airflow through either the mouth or nose lasting more than 10 seconds.

Apnea may be obstructive (accompanied by thoracoabdominal movements) or central (not accompanied by such movements). Mixed apnea begins as central and ends as obstructive apnea. A decrease in oronasal airflow of more than 50% accompanied by oxygen desaturation of 4% or by arousal is termed hypopnea. Airflow was evaluated by an oronasal thermistor alone.

2. For the other analysis, we applied the 2002 SEPAR guidelines, which propose the use of a thermistor, nasal pressure cannula, and thoracoabdominal bands, but not esophageal pressure catheters to detect respiratory events. Obstructive apnea is defined as the absence of or more than 90% reduction in the respiratory signal lasting more than 10 seconds and accompanied by respiratory effort detected by thoracoabdominal bands. If not accompanied by respiratory effort, the apnea is central. Mixed apnea begins as central and ends as obstructive apnea. Hypopnea is a discernible (between 30% and 90%) reduction in the amplitude of the respiratory signal lasting more than 10 seconds and is accompanied by oxygen desaturation of 3% and/or arousals. RERAs are defined as periods of progressive increase in respiratory effort lasting more than 10 seconds and usually ending in arousal. These are generally detected by means of esophageal pressure catheters, although a nasal pressure cannula and thoracoabdominal bands can also be used.

Using both sets of guidelines, we determined the number of apneas and hypopneas and calculated the apnea index, hypopnea index, and AHI. We also calculated the percentage with which each of the 2 indices, for apneas and hypopneas, contributed to the overall AHI.

RERAs were included in the group of hypopneas according to the 2002 guidelines. Sleep studies were read by a single reader who first determined the sleep stages and arousals to be applied in the interpretations by both sets of guidelines and then analyzed respiratory events manually, blindly, and separately for each set of criteria (1993 and 2002). The following reading method was used: the polysomnographic studies of all patients were recorded onto 2 different set of computer disks; the first group of disks, in which information from the nasal pressure cannula channel had been eliminated for each patient, was read consecutively according to the 1993 guidelines and then the second group was read according to the 2002 guidelines.

Statistical Analysis

Statistical analysis was carried out using SPSS version 11.0 (2001) software (SPSS Inc., Chicago, Illinois, USA). The descriptive statistics have been expressed as means (SD) or a percentage, depending on the nature of the variables. The Student t test was used to compare values for each of the variables obtained with the two guidelines. The level of significance was set at a 95% probability level. The Bland and Altman[10] method was used to graphically display the degree of agreement and biases between the 2 methods of assessing the AHI. Average AHI values according to both sets of guidelines were plotted on the abscissa and the difference between the 2 values on the ordinate.

Results

Of the 120 polysomnography studies, 2 were rejected: 1 because of artifacts, as a nasal vasoconstrictor needed to be administered on 2 occasions during the night in order to improve the quality of the recordings, and the

other because the patient slept for less than 180 minutes. Minor problems were observed with the signal quality of the nasal pressure cannula during the study of 10 patients (8.47%), but these did not prevent the identification of respiratory events. The characteristics of the 118 patients evaluated were as follows: 80% men and 20% women; mean age, 51 (11.6) years; body mass index, 31.1 (4.3); neck circumference 41.8 (3.9). Mean values for sleep parameters were as follows: efficiency, 81.4% (14.3%); light sleep (stages 1 and 2), 68.1% (12.3%); deep sleep (stages 3 and 4), 15.2% (6.8%); and REM, 16.7% (6.2%). Distribution according to severity of SAHS using the 1993 guidelines was as follows: 25 patients had simple snoring (AHI<10), 38 had mild-to-moderate SAHS (AHI, 10-29, and 55 had severe SAHS (AHI≥30).

Table 1 shows mean absolute values for AHI, and apnea and hypopnea indices applying the 1993 and 2002 guidelines, as well as percentage of AHI attributable to apneas and hypopneas for each group. A significant difference ($P<.05$) of 11.86 points was observed between mean AHI values. There was a difference of 8.25 points ($P<.05$) in the apnea index and a difference of 3.61 points ($P<.05$) in the hypopnea index. The differences between the percentages were not significant ($P>.05$).

Table 2 shows the mean AHI, and apnea and hypopnea indices for each of the subgroups, obtained by classifying the patients into the 3 categories of severity mentioned above according to the 1993 guidelines; beside these values, the corresponding values using the 2002 guidelines are shown. We obtained the following results:
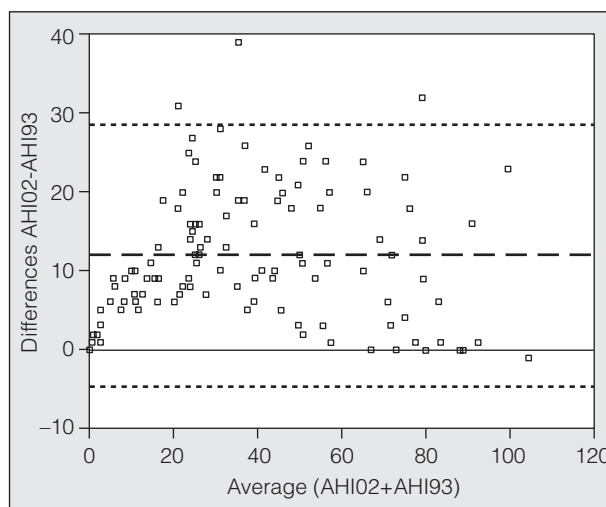

Figure. Bland and Altman plot. Differences in AHI values (ordinate) between 2002 and 1993 methods of measurement plotted against the average values of the 2 methods (abscissa). The mean is defined by the broken line (– – – –) and the limits of agreement (mean ±1.96×SD) by the dotted line (-------). For the group as a whole, AHI was almost always above the line of identity (zero difference), reflecting the underdiagnosis that results from the use of the 1993 guidelines.

1. Between-group differences in the mean AHI were significant, with differences of 7.32 points in simple snorers, 16.05 points in patients with mild-to-moderate SAHS, and 11.03 points in patients with severe SAHS.

2. In the 2 subgroups with AHIs less than 30, the apnea indices were 0.72 and 2.97 points higher and the hypopnea indices were 6.60 and 13.08 points higher, respectively. In patients with severe SAHS, the apnea index increased by 13.92 points and the hypopnea index decreased by 2.89. All differences were significant ($P<.05$) except for the hypopnea index in severe SAHS.

3. The percentage of the AHI attributable to apneas and hypopneas did not vary significantly in the first 2 subgroups, but did in the subgroup of patients with severe SAHS.

By using the AHI cutoff point of 10 as indicative of SAHS, 64% (16 out of 25) of the patients classified as simple snorers according to the1993 guidelines were considered to have SAHS according to those of 2002, and by using the cutoff point of 30 for initiation of CPAP treatment, 47.61% (30 out of 63) of the patients considered not to need CPAP according to the 1993

TABLE 1
Mean Values of Respiratory Event Indices Applying 1993 and 2002 SEPAR Guidelines in the 120 Patients*

Index	SEPAR 1993	SEPAR 2002
AHI	33.16 (26.51)	45.02† (26.57)
AI	14.25 (23.20), 42.98%	22.50† (27.63), 49.97% NS
HI	18.90 (16.06), 57.02%	22.51† (16.04), 50.03% NS

*Results are expressed as mean (SD), followed by the percentage of the AHI attributable to apneas or to hypopneas. SEPAR indicates Spanish Society of Pulmonology and Thoracic Surgery**;** AHI, apnea-hypopnea index; AI, apnea index; HI, hypopnea index; NS, not significant ($P>.05$).
†Statistically significant result ($P<.05$).

TABLE 2
Mean Values of Respiratory Event Indices Applying 1993 and 2002 SEPAR Guidelines According to Level of Severity*

Index	SEPAR 1993					SEPAR 2002				
	Mean AHI	Mean AI	Mean HI	AI in AHI	HI in AHI	Mean AHI	Mean AI	Mean HI	AI in AHI	HI in AHI
AHI<10	4.04	0.24	3.80	5.94%	94.06%	11.36†	0.96†	10.40†	8.45% (NS)	91.55% (NS)
AHI 10-30	18.10	2.84	15.26	15.70%	84.30%	34.15†	5.81†	28.34†	17% (NS)	83% (NS)
AHI≥30	56.80	28.50	28.30	50.20%	49.80%	67.83†	42.42†	25.41 (NS)	62.53%†	37.47%†

*Results are expressed as means. SDs have been omitted for the sake of simplicity.
SEPAR indicates Spanish Society of Pulmonology and Thoracic Surgery; AHI, apnea-hypopnea index; AI, apnea index; HI, hypopnea index; AI in AHI, percentage of AHI attributable to apneas; HI in AHI, percentage of AHI attributable to hypopneas; NS, not significant ($P>.05$).
†Statistically significant result ($P<.05$).

guidelines did need such therapy according to the 2002 guidelines.

Comparison of the 2 sets of guidelines showed a systematic bias that can be seen in the Bland and Altman plot (Figure). For the group as a whole the AHI was almost always above the line of identity corresponding to 0 on the ordinate axis.

We constructed a regression model with a significance level of 5% (*P*<.05) in which the 1993 AHI was considered the independent variable and the 2002 AHI the dependent variable. The following equation was obtained: AHI (2002) =13.49+0.95·AHI (1993).

Discussion

As expected, there were noteworthy significant differences between results with the 1993 and 2002 SEPAR guidelines for the total sample of patients both in AHI values (difference between the means, 11.86 points) and in the apnea and hypopnea indices taken separately. These findings are similar to those described by various authors in studies carried out with similar objectives, but using slightly different criteria to classify respiratory events. Thus, Sériès and Marc[11] found a difference of 8.8 points in patients with sleep-disturbed breathing when measuring the events with a thermistor versus a nasal pressure cannula, and Hernández et al[12] a difference of 7 points in subjects representing the general population and 10 in patients with suspected SAHS. Similar results have been described in children as well.[13] The differences in our study were due to the fact that the 1993 guidelines only recommended the use of a thermistor/thermocouple to measure respiratory events, and this device provides only a semiquantitative measure of respiratory events with nonlinear response and a long time constant.[14] Signal quality depends on the airflow pattern (amplitude, form, and frequency of the respiratory wave) and various geometric characteristics (distance from the nose and the area of the cross section of the nostrils).[15] Thus, the ability of the thermistor/thermocouple to measure some respiratory events is limited, and for this reason the 2002 guidelines added the nasal pressure cannula and esophageal pressure catheters, thus improving the accuracy of detection.

After dividing the group of patients into 3 subgroups according to the AHI cutoff points established in the 1993 SEPAR guidelines, we observed that differences between mean AHI values remained significant (Table 2). These differences were greater in the subgroups of mild-to-moderate SAHS and less pronounced in the other 2 subgroups. Other authors[4,16-18] have observed that it is when a nasal pressure cannula or an esophageal pressure catheter is used, or both together, as opposed to a thermistor/thermocouple that the greatest differences in the number of hypopneas and RERAs (events that predominate in cases of mild-to-moderate SAHS) detected is observed. As a correction mechanism, it is important to take the precaution of assessing arousals and/or oxygen desaturation at the end of an event. In this way, the

overdiagnosis of respiratory events by nasal pressure cannula compared to esophageal pressure catheters[19] or pneumotachography is avoided.[20] Even thoracoabdominal bands overdiagnose such events compared to esophageal pressure catheters[21] or pneumotachography[20] if not accompanied by the correction mechanism mentioned above.

The contribution of the apnea and hypopnea indices to the AHI did not vary significantly in the 2 lower-severity subgroups. This apparent paradox was due to the fact that the detection of apneas increased with the 2002 guidelines, principally for 2 reasons: *a)* due to its nonlinear response the nasal pressure cannula overestimates high flows and underestimates low flows compared to pneumotachography[5,22] and tends to classify hypopneas with low-amplitude signals as apneas, and *b)* the 2002 guidelines do not require complete cessation of airflow for a respiratory event to be defined as apnea. A similar increase was noted by Sériès and Marc,[11] who observed that 39% of the hypopneas detected by the thermistor were identified as apneas by the nasal pressure cannula.

However, one must be careful not to confuse apneas with exclusively oral breathing (false positives). Such confusion can be avoided by considering as apneas only those events that terminate in arousals and/or oxygen desaturation, by using a thermistor in combination with the nasal pressure cannula in order to measure oral airflow, or by linearizing the raw data signal for the pressure wave obtained with the nasal pressure cannula by means of the following equation: pressure = K· flow.[2] This last method has given good results in laboratory studies[5,22] but somewhat less satisfactory results in clinical studies.[20,23]

The different behavior of the percentages in severe SAHS was due to the predominance of apneas over hypopnea and RERAs in these patients.[18,24]

In view of our finding that 64% of those patients classified as simple snorers according to the 1993 criteria were considered to have SAHS and that 47.61% of those not considered to need CPAP therapy were considered to need it when the 2002 criteria were applied, it might be opportune to raise the question of the possibility of changing (updating?) the cutoff points for the diagnosis of SAHS and initiation of CPAP treatment established in the 1995[2] and 1998 guidelines.[3] Some authors[24] have already proposed such a change and others have already adopted the measure: Rees et al[25] considered the upper limit of the normal range to be 15; Hosselet et al, 18; and Norman et al, 20. Such changes should be based on clinical and epidemiological studies specifically designed for the purpose and are beyond the scope of the present study. While raising the cutoff point for the diagnosis of SAHS would probably not involve significant therapeutic changes, modifying it for making treatment decisions would involve changes in the number of prescriptions for CPAP, especially in the subgroup of patients with mild-to-moderate SAHS.

Another possible point of controversy is the question of whether the 2002 SEPAR criteria actually detect real respiratory events that went unnoticed with those of the previous guidelines, or whether they in fact overestimate and mislabel physiological phenomena. We believe the novelties introduced in the most recent guidelines to be based on conclusive evidence, and therefore reject the second hypothesis.

The principal limitation of the present study lies in the fact that we did not use esophageal pressure catheters to detect respiratory events. The use of an esophageal pressure catheter is the gold standard for measuring respiratory effort, as is the use of a pneumotachograph for measuring airflow. The nasal pressure cannula in combination with a thermistor and the thoracoabdominal bands that were used in the present study are a second option, as estimates based on esophageal pressure catheters show good agreement with those of both nasal pressure cannulas[19] and thoracoabdominal bands.[21] We believe that the method used in the present study was appropriate and that the use of esophageal pressure catheters would not have produced notable variations in the results.

In summary, the recent 2002 SEPAR guidelines improve the detection of respiratory events, as there are significant differences in AHI, and in both apnea and hypopnea indices depending on whether the 2002 or 1993 guidelines are applied. These findings raise the question of whether it would be opportune to initiate a debate regarding the possibility of changing the cutoff points for diagnosing SAHS and for prescribing CPAP treatment. These cutoff points have not been modified since they were established in the 1990s.

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