Comparison of AutoSet™ and polysomnography for the detection of apnea-hypopnea events

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Abstract

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The use of the flow *vs* time relationship obtained with the nasal prongs of the AutoSet™ (AS) system (diagnosis mode) has been proposed to detect apneas and hypopneas in patients with reasonable nasal patency. Our aim was to compare the accuracy of AS to that of a computerized polysomnographic (PSG) system. The study was conducted on 56 individuals (45 men) with clinical characteristics of obstructive sleep apnea (OSA). Their mean (± SD) age was 44.6 ± 12 years and their body mass index was 31.3 ± 7 kg/m^2. Data were submitted to parametric analysis to determine the agreement between methods and the intraclass correlation coefficient was calculated. The Student *t*-test and Bland and Altman plots were also used. Twelve patients had an apnea-hypopnea index (AHI) <10 in bed and 20 had values >40. The mean (± SD) AHI$_{PSG}$ index of 37.6 (28.8) was significantly lower (P = 0.0003) than AHI$_{AS}$ (41.8 (25.3)), but there was a high intraclass correlation coefficient (0.93), with 0.016 variance. For a threshold of AHI of 20, AS showed 73.0% accuracy, 97% sensitivity and 60% specificity, with positive and negative predictive values of 78% and 93%, respectively. Sensitivity, specificity and negative predictive values increased in parallel to the increase in AHI threshold for detecting OSA. However, when the differences of AHI$_{PSG-AS}$ were plotted against their means, the limits of agreement between the methods (95% of the differences) were +13 and -22, showing the discrepancy between the AHI values obtained with PSG and AS. Finally, cubic regression analysis was used to better predict the result of AHI$_{PSG}$ as a function of the method proposed, i.e., AHI$_{AS}$. We conclude that, despite these differences, AHI measured by AutoSet™ can be useful for the assessment of patients with high pre-test clinical probability of OSA, for whom standard PSG is not possible as an initial step in diagnosis.

Introduction

Obstructive sleep apnea (OSA) affects 2-4% of the middle-aged population (1). This condition is associated with an increase in cardiovascular morbidity and mortality (2,3), sleepiness and changes in daytime cognitive functions (4,5). Consequently, the number of patients requiring an all-night polysomnographic recording (PSG) is also high. How-

ever, due to the relatively small number of sleep disorders laboratories and to the excessive cost of PSG, alternative, less expensive and simplified but reliable techniques are needed for the diagnosis of the population of patients with suspected OSA. The AutoSet™ (AS) (ResCare Ltd., Sydney, Australia) in the recently introduced diagnostic mode (6-8) allows an immediate analysis of flow/time curves which permits the detection of apneas, hypopneas and upper airway resistance (9). This method is quite accessible and requires only the application of prongs to the nostrils and the use of a pulse oxymeter on one finger.

Our aim was to compare the accuracy of AS for the diagnosis of OSA with that of a computerized PSG system in 56 subjects with clinical characteristics of OSA.

Material and Methods

Sixty-three patients were evaluated and seven were excluded due to technical problems: 5 patients with dislodgment of the nasal prongs from the nostrils at a specific time during the night and 2 patients due to recording problems with the AS. Thus, 56 patients (45 men and 11 women) with suspected clinical OSA but without other associated diseases were investigated in a prospective study. The mean age (± SD) of the patients was $44.6 ± 12$ years (range: 13 to 69 years) and mean body mass index was $31.3 ± 7$ kg/m^2 (range: 19 to 56 kg/m^2).

All patients were submitted to full-night PSG using an Oxford Medilog SAC™ Sleep Analyzing Computer system (Oxford Instruments plc, Oxford, UK) and the following parameters were recorded: electroencephalogram (EEG), electro-oculograms, submental electromyogram, electrocardiogram, digital pulse oxymetry, oral and nasal airflow, chest and abdominal movement, and body position. All PSG respiratory events (with the apnea-hypopnea index (AHI) considered for total time recorded) and sleep staging

data were manually scored according to the criteria of Rechtschaffen and Kales (10) by an experienced staff member. The criteria adopted to define respiratory events were a) apneas characterized by absence of, or drop in, airflow higher than 80% in relation to basal values, associated or not with alterations in chest and abdominal movements for more than 10 s; b) hypopneas, characterized by a drop in airflow between 50 and 80% of basal values, for more than 10 s, associated with an oxygen destruction of ≥4% or arousal, and c) AHI, characterized by the sum of apnea and hypopnea events/total recording time (TRT). Traditionally, the AHI is calculated as the ratio of apneas and hypopneas/total sleep time; however, the AS just reports the AHI during TRT, since it does not record the EEG. So, to compare this parameter in both systems (PSG and AS) we just considered the AHI related to TRT. Twelve patients presented with an AHI <10 and 20 with an AHI >40. Concurrently with classic PSG recordings, patients were also connected to the AS in the diagnostic mode, with a nasal prong carefully placed on the nostrils in parallel to a thermal airflow from the Oxford System according to the method of Norman et al. (11). Another digital pulse oxymeter for the AS was installed on a different finger of the same hand where the first oxymeter had been positioned.

The AS has two functional modes: diagnostic and treatment. In the diagnostic mode, the AS pressure transducer evaluates the flow generated in the nostrils through standard nasal cannulae. The internal pressure transducer and the system software allow the estimation of airflow and of the flow/time relationship (12). Snoring is qualitatively assessed by analyzing the flow signal after band-pass filtering. Using a Biox 3700e external digital oxymeter (Ohmeda, Essex, UK), nocturnal arterial oxygen saturation is measured and recorded simultaneously. The apnea and hypopnea detector is triggered if there is a decrease in ventilation of 50% or

more, averaged over any 10-s interval. Both PSG and AS had their clocks synchronized and recordings were started simultaneously for both devices.

Statistical analysis

The AHI values obtained by PSG and AS were analyzed as follows: AHI values were first analyzed descriptively to determine their normality using the Skewness and Kurtosis tests. The paired Student t-test was then applied to compare the AHI results obtained by the two methods. The intraclass correlation coefficient (ICC) and its variance were then calculated to determine the agreement between methods. Agreement between AHI obtained by PSG and by AS was also evaluated using the Bland and Altman plots (13) simply to show the trends and variability for the two methods. Sensitivity, specificity, and the positive (PPV) and negative predictive values (NPV) of data related to AS were obtained independently for AHI thresholds of 10, 20 and 40. Finally, regression analysis was used to predict the result of AHI_{PSG} (gold standard) as a function of the proposed AHI_{AS} method, and the one that provided the best fit was chosen (Figure 1).

Results

The ICC was 0.935, with 0.016 variance, showing that it was estimated with very high precision even though the mean AHI assessed by PSG was 37.6, i.e., significantly lower than values assessed by AS (41.8; P = 0.0003; Student t-test). Also by the Bland and Altman plots the mean difference between the AHI obtained by the two methods (PSG and AS) was -4.2 ± 8.9, which, when plotted against the means (AHI_{PSG} + AHI_{AS}/ 2), demonstrated the discrepancy between the AHI values calculated by the two methods. The limits of agreement (±2 SD) between the two methods (95% of the differences) were +13 and -22. There was a ten-

dency of AS to overscore AHI, which vanished when values of AHI_{PSG} were higher than 60 (Figure 2). After these thresholds (AHI_{PSG} = 60), the mean values of AHI_{PSG} and AHI_{AS} were 72.9 and 75.9, respectively (P = 0.48) and the mean AHI_{PSG}-AHI_{AS} difference was 3.01 ± 9.5. The accuracy, sensitivity, specificity and PPV and NPV of AS for threshold values of 10, 20 and 40 are presented in Table 1. Finally, regression analysis of AHI_{PSG} values in relation to those obtained by AHI_{AS} showed that the best function was a 3rd degree polynomial (cubic regression) (Y = 5.73482 - 0.19885 X + 0.0278 X^2 - 0.000168 X^3) with R = 0.926 (Figure 1).
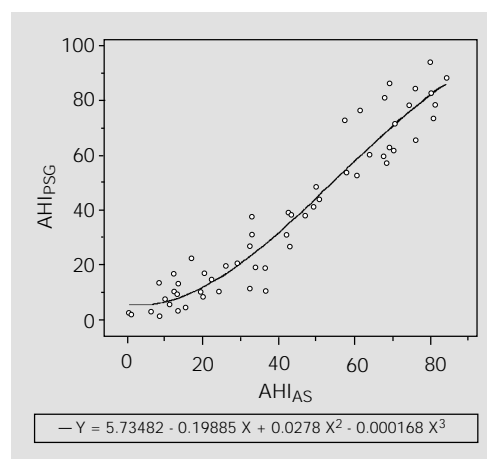

Figure 1 - Regression analysis of the relationship of AHI_{PSG} values to those obtained by AHI_{AS}. AHI: Apnea-hypopnea index; PSG: polysomnography; AS: AutoSet™.
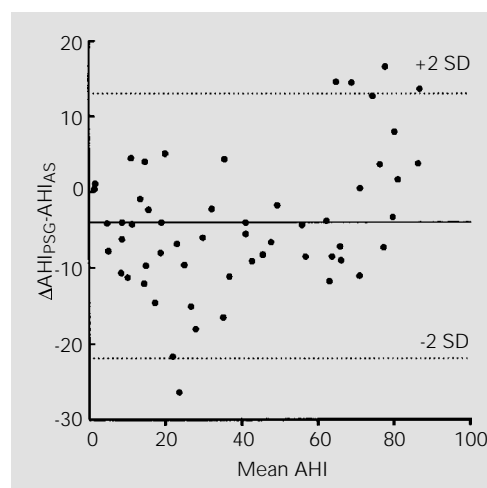

Figure 2 - Differences (Δ) of AHI (PSG-AS) plotted against the mean for each patient. The solid line represents the mean difference and the dashed lines indicate the limits of agreement (±2 SD). AHI: Apnea-hypopnea index; PSG: polysomnography; AS: AutoSet™; SD: standard deviation.

Table 1 - Accuracy, sensitivity, specificity, and positive (PPV) and negative predictive values (NPV) of AutoSet™ as compared to Oxford PSG in patients suspected to have OSA.

AHI: Apnea-hypopnea index.

AHI threshold	10.0	20.0	40.0
Accuracy (%)	91.0	73.0	50.0
Sensitivity (%)	97.8	96.9	100.0
Specificity (%)	40.0	60.0	87.0
PPV (%)	88.0	78.0	85.0
NPV (%)	80.0	93.3	100.0

Discussion

Population awareness of OSA, especially in developing countries, is unlikely. This problem is further compounded by the fact that in Brazil epidemiological data on snoring and daytime sleepiness are limited (14). Costs of performing traditional PSG recordings are high and public and most private health insurance policies do not cover diagnostic and therapeutic procedures. This, despite the cardiovascular risks (2,3) and the impaired daytime cognitive function, a recognized co-factor in the etiology of occupational and road traffic accidents (15). The development of simpler and less expensive diagnostic methods, particularly for typical cases, is urgently needed. History, physical examination, observation during sleep and pulse oxymetry yield limited diagnostic data (16,17). AS is a simple, low-cost method which does not demand complex technical expertise, allowing even home monitoring. One limitation of AS for diagnosing OSA is in relation to patients with nasal diseases, particularly those with mouth respiration at night. The high ICC with low variance shows the high concordance between AHI_{PSG} and AHI_{AS}. However, despite these results, the Student t-test showed significantly lower AHI_{PSG} values than AHI_{AS} values and a poor

agreement between methods when AHI_{PSG} and AS_{AS} where analyzed according to the Bland and Altman plot (13) (Figure 2). The tendency of AS to overvalue AHI was reported by us and by others (6-8), however, these investigators assumed a linear relationship between AHI obtained by two systems. As observed in Figure 1, we described an original data 3rd degree polynomial (cubic regression) that best related AHI and PSG.

The distribution of the differences of AHI_{PSG-AS} *vs* their means (Figure 2) showed a tendency of AHI_{AS} to overvalue AHI_{PSG} up to an AHI value of 60. However, this tendency disappeared with AHI >60, when our patients presented with a typical picture of the syndrome. Also, as seen in Figure 1, we can reliably predict the AHI by using the AS if a more sophisticated analysis is performed. The sensitivity and specificity of AS (97% and 40% for an AHI threshold of 10, respectively) increased in parallel to the increased threshold of AHI (Table 1). This permits physicians to readily identify patients with an AHI above 40, with greater sensitivity (100%) and specificity (87%) than for a lower AHI threshold value. The NPV likewise tended to increase with the severity of the disturbance, thereby highlighting the rarity of a negative test for a high AHI value obtained by PSG. We conclude that AS can be useful in the assessment of patients with high pre-test clinical probability of OSA who cannot be submitted to standard PSG as the first step toward diagnosis.

Acknowledgments

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