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The utility of current criteria for split-night polysomnography for predicting CPAP eligibility

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Abstract

Introduction Traditionally, evaluation of obstructive sleep apnea (OSA) has consisted of a diagnostic polysomnogram (PSG), followed by a continuous positive pressure (CPAP) titration. However, to reduce costs, many third-party payers mandate performance of split-night studies (SPL), combining diagnostic and CPAP titration testing. We ascertained the utility of performing SPL for diagnosis and treatment of OSA.

Methods We reviewed the PSG records of 200 patients suspected of having OSA. Using both American Academy of Sleep Medicine (AASM) and Medicare (CMS) criteria for scoring, we calculated the sensitivity, specificity, positive (PPV), and negative predictive value (NPV) of the AHI in the first 2 h of sleep for predicting an overall AHI $\geq$ 15.

Results For predicting an overall AHI $\geq$ 15, the sensitivity, specificity, PPV, and NPV of an AHI (AASM criteria) $\geq$ 40 in the first 2 h were respectively: 0.304, 1.000, 1.000, and 0.335. For an AHI $\geq$ 20 in the first 2 h, the corresponding values were 0.770, 0.962, 0.983, and 0.595. Corresponding values using CMS criteria were 0.347, 1.0, 1.0, and 0.6 for AHI > 40, and 0.693, 0.99, 0.986, and 0.76 for AHI $\geq$ 20, respectively.

Conclusion For justification of CPAP (overall AHI $\geq$ 15), the sensitivity is slightly lower when using an AHI $\geq$ 40 vs AHI $\geq$ 20, but the specificity and PPV are much higher. Using AHI $\geq$ 20 as criteria for SPL as opposed to the guideline criteria of AHI $\geq$ 40 may be more effective in obtaining CPAP for patients with moderate to severe OSA.

Keywords Obstructive sleep apnea · Split night studies · CPAP titration · Polysomnography · Apnea-hypopnea index

Introduction

Obstructive sleep apnea (OSA) is a common medical disorder, affecting up to 26% of the general working age population [1]. It is recognized as a major contributor to cardiovascular morbidity, being associated with increased rates of cerebrovascular disease, systemic hypertension, ischemic heart disease, cardiac arrhythmias, congestive heart failure, pulmonary vascular disease, and pulmonary hypertension [2, 3]. Classically, the evaluation of OSA has consisted of two separate full night in-laboratory polysomnograms (PSG); an initial diagnostic PSG followed by a therapeutic PSG in which continuous positive airway pressure (CPAP) is upwardly titrated to optimally treat disordered breathing events. Home testing for diagnosis of OSA has gained greater acceptance lately as well [4]. While all-night in-laboratory studies remain the gold standard, several third-party payers now mandate that for an in-laboratory study to be authorized, it must be performed as a so-called split-night PSG (SPL).

SPL consists of combining the diagnostic PSG and the CPAP titration into a single-night study. The American Academy of Sleep Medicine's (AASM) recommended criteria for adding CPAP during a SPL include an apnea-hypopnea index (AHI, events/h) $\geq$ 40 in the first 2 h of sleep during a diagnostic PSG, as well as at least 3 h remaining in the study for the adequate titration of CPAP [5]. In cases where there is high clinical suspicion, an AHI $\geq$ 20 in the first 2 h of sleep may be used at the provider's discretion. If criteria are not met, the study is completed as a diagnostic PSG, and a second full night CPAP titration is needed.

To our knowledge, few studies have investigated the initial 2-h AHI as a predictor of CPAP eligibility (AHI $\geq$ 15) in those patients in whom SPLs are ordered and performed according

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to the AASM criteria. With many insurance providers, patients are eligible for CPAP titration and treatment with an overall AHI ≥ 5 per hour. In the USA, however, one of the primary insurance providers is Medicare (CMS). According to CMS criteria, only patients with moderate to severe OSA (AHI ≥ 15) or an AHI of 5 to15 in the setting of certain specific comorbid conditions [5] qualify for titration and treatment with CPAP. These conditions include associated documented symptoms of excessive daytime sleepiness, impaired cognition, mood disorders or insomnia, or documented hypertension, ischemic heart disease, or history of stroke [6].

Given the mandates of certain third-party payers to perform SPL in lieu of two separate studies, we wished to examine the utility of routine ordering of SPL for the diagnosis and treatment recommendations of OSA. Specifically, we evaluated the ability of the AHI within the first 2 h of sleep to predict patients' eligibility for CPAP, requiring overall AHI ≥ 15 in the absence of any qualifying comorbid conditions [5]. We tested the hypothesis that most patients with OSA will be able to be studied in one night using the AASM (AHI > 40 or AHI > 20) criteria for starting CPAP [6].

Methods

The clinical records of 200 adult patients referred to the University of Maryland Sleep Disorders Center from July 2016–January 2017 were retrospectively reviewed. The review included patients who were suspected of having OSA. We included patients in whom a sleep study (diagnostic PSG) was ordered by the treating physician, and authorized by insurance providers.

All PSG were performed by licensed and registered PSG technologists in attendance at the Sleep Laboratory of the Sleep Disorders Center at the University of Maryland, an AASM accredited facility. All subjects underwent overnight PSG using standard techniques and scoring criteria for sleep stages (EEG and submentalis EMG), leg movements (anterior tibialis EMG), and arousals from sleep [7, 8]. Airflow was measured by nasal pressure cannula and arterial oxyhemoglobin saturation by pulse oximetry. Respiratory effort was assessed using thoracoabdominal movements (respiratory inductance plethysmography). All PSG studies were performed using the same equipment and software (Philips Respironics—Alice 2.8.78), scored by certified licensed technologists and reviewed and interpreted by board-certified sleep medicine specialists. OSA severity was computed by counting the number of apneas plus hypopneas per hour of sleep. Apneas were scored as reduction in airflow by at least 90% of the baseline for at least 10 s. Hypopneas were scored retrospectively using both AASM and CMS criteria (Table 1) [10, 11].

Data were obtained from the PSG including the overall AHI (apneas + hypopneas per hour of sleep), the AHI during the first 2 hours of sleep, sleep efficiency, and sleep staging. Additionally, we collected demographic data including gender, age, and body mass index, as well as Epworth sleepiness scores [12, 13], and common comorbid conditions including renal disease, hypertension, other cardiovascular disease, cerebrovascular disease, diabetes, mood disorders, and chronic lung disease. Medical histories, and Mallampati score [14, 15], were taken from the electronic medical record.

The primary endpoint was to determine the ability of the AHI in the first 2 hours of sleep to predict eligibility for CPAP based on an overall AHI ≥ 15. The justification for this end was that all major insurance carriers authorize CPAP treatment for patients with overall AHI ≥ 15, irrespective of comorbidities. We calculated sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of the initial 2-h AHI, scored both according to AASM and CMS criteria, to predict the overall AHI ≥ 15. A secondary endpoint was to determine if any comorbid conditions or demographics

Table 1 AASM and CMS criteria for scoring hypopneas [9]

AASM criteria for scoring hypopneas	CMS criteria for scoring hypopneas
Recommended	Recommended
1. Score a respiratory event as a hypopnea if all of the following criteria are met:	1. Score a respiratory event as a hypopnea if all of the following criteria are met:
a. The peak signal excursions drop by ≥ 30% of the pre-event baseline using nasal pressure (diagnostic study), PAP device flow (titration study), or an alternative hypopnea sensor (diagnostic study).	a. The peak signal excursions drop by ≥ 30% of the pre-event baseline using nasal pressure (diagnostic study), PAP device flow (titration study), or an alternative hypopnea sensor (diagnostic study).
b. The duration of the ≥ 30% drop in signal excursion is ≥ 10 s.	b. The duration of the ≥ 30% drop in signal excursion is ≥ 10 s.
c. There is a ≥ 3% oxygen desaturation from pre-event baseline and/or the event is associated with an arousal.	c. There is a ≥ 4% oxygen desaturation from pre-event baseline.
or	
a and b above and there is a ≥ 4% oxygen desaturation from pre-event baseline	

AASM American Academy of Sleep Medicine, *CMS* Centers for Medicare Services

Table 2 Demographic and comorbid condition of the study population

Demographics of study population	
Entire cohort	200
Male	98 (49%)
Female	102 (51%)
Race	
Caucasian	126
African American	63
Other	11
Age [a]	19–77 (41 ± 12.3)
Body mass index (kg/m^2)[a]	37.07 (± 10.5)
Mallampati score[b]	3.25 (3–4)
Epworth sleepiness score[a]	10.15 (± 4.94)
Comorbid conditions	
Hypertension	113 (56.5%)
Mood disorder (depression/anxiety)	78 (39.0%)
Cerebrovascular/stroke	8 (4.0%)
Renal disease	7 (3.5%)
Chronic lung disease—chronic obstructive pulmonary disease/asthma	45 (22.5%)
Congestive heart failure	8 (4.0%)
Coronary artery disease	15 (7.5%)
Arrhythmia	12 (6.0%)
Diabetes	46 (23.0%)

Also shown: number (percent total)

[a] Mean ± SD

[b] Median value (interquartile distance)

increased the sensitivity of the AHI in the first 2 hours for predicted CPAP eligibility.

Data analysis

Data were collected and collated. Statistical analysis was done using Sigmaplot 12.0 (Systat software, San Jose, CA). Normally distributed data (Komogorov-Smirnoff test) were expressed as mean ± standard deviation (SD). Non-normally distributed data were expressed as median (interquartile distance). The sensitivity and specificity and positive and negative predictive values were calculated for predicting overall AHI ≥ 15, for both the initial 2-h AHI ≥ 40 and ≥ 20. Correlation was tested using least-squares analysis. Statistical significance of proportions was testing using chi-square analysis. The null hypothesis was rejected at the 5% level.

Results

The demographics of the study population, as well as other clinical information are displayed in Table 2, including several relevant comorbid conditions. Overall, 200 cases were reviewed, including 98 men and 102 women, ages 19–77 (41 ± 12.3).

Table 3 shows the test statistics for predicting an AHI ≥ 15 for an initial AHI ≥ 40 and an initial AHI ≥ 20 specifically using the AASM scoring criteria for all 200 patients. When using the criteria of an AHI ≥ 40 to perform a SPL, the sensitivity of having an overall AHI ≥ 15 is 30.3%, while the specificity is 100%. With the use of an AHI ≥ 20 used as the criteria for splitting, the sensitivity increases to 77%, and the specificity is 96.2%. The positive predictive value of predicting an overall AHI ≥ 15 with a 2-h AHI ≥ 40 and AHI ≥ 20 is 100% and 98.3% respectively. The negative predictive values are 33.5% and 59.5% for the 2-h AHI ≥ 40 versus ≥ 20 to predict an overall AHI ≥ 15 respectively. The linear regression models for each of these AHI cutoffs for predicting overall AHI ≥ 15 by both AASM and CMS criteria are shown in Figs. 1 and 2 respectively. When using the CMS scoring criteria, the test statistics for predicting an AHI ≥ 15 for an initial AHI ≥ 40 and an initial AHI ≥ 20 are similar; these are shown in Table 4.

We tested the presence of specific comorbid conditions for predicting an overall AHI ≥ 15. Only the presence of hypertension significantly changed sensitivity and specificity of initial AHI for predicting AHI ≥ 15 and CPAP eligibility. As shown in Table 5, the univariate p values for hypertension when using both AASM and CMS scoring criteria were statistically significant at $p = 0.015$ and $p = 0.012$ respectively. However, when adjusting for multiple comparisons (Bonferroni's correction), the p values

Table 3 Statistics of 2-h AASM AHI predicting CPAP eligibility

	AHI by AASM ≥ 40 predicting overall AHI ≥ 15	AHI by AASM ≥ 20 predicting overall AHI ≥ 15
Sensitivity	30.4%	77.0%
Specificity	100%	96.2%
Positive predictive value	100%	98.3%
Negative predictive value	33.5%	59.5%

AHI apnea-hypopnea index, *AASM* American Academy of sleep medicine, *CPAP* continuous positive airway pressure

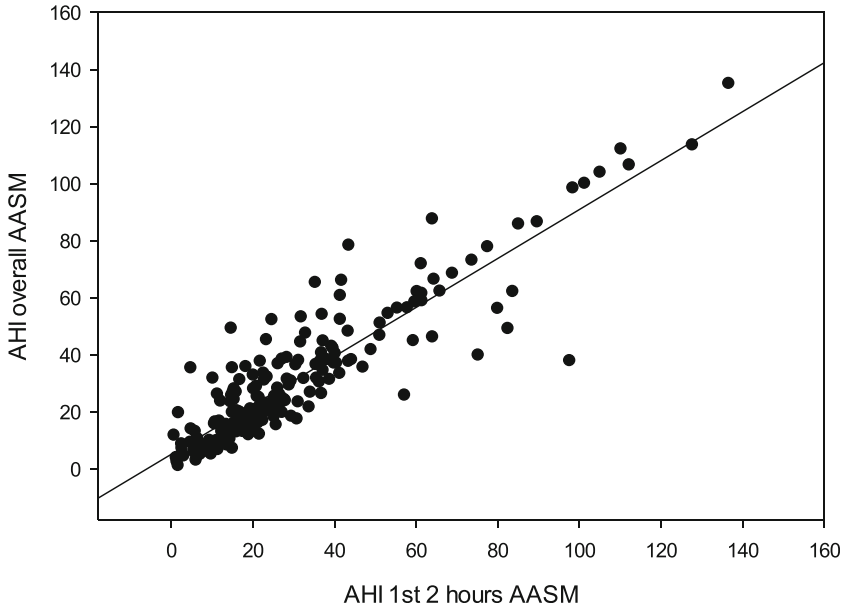

Fig. 1 Linear regression model of the AHI in the first 2 h of sleep vs the overall AHI as per the AASM definition. The regression line is $Y = 5.188 + (0.857 \times X)$; $R^2 = 0.813$; $P < 0.001$. AHI apnea-hypopnea index, AASM American Academy of Sleep Medicine

for the regression are above the level of statistical significance ($P = .075$ and .060 respectively).

Discussion

In this single-center retrospective study, we examined the utility of routine ordering of SPL for both the diagnosis and treatment of OSA. The major finding in our study was that using AHI $\geq$ 40, whether scored using AASM or CMS definitions for hypopneas, in the first 2 h of sleep has a low sensitivity for predicting an overall AHI $\geq$ 15, which calls for treatment with CPAP therapy. When using an AHI $\geq$ 20 the sensitivity was improved with only a small loss of specificity. In the ensuing discussion, we consider these findings in the light of the currently available literature.

While prior studies have evaluated the use of the above AHI cutoffs to perform SPL, few if any have evaluated the use of SPL to predict a patient's qualification for CPAP therapy using an overall AHI of $\geq$ 15. This level of severity was chosen because at an AHI $\geq$ 15, represents moderate OSA where virtually all third-party payers will approve a patient for PAP therapy, even in the absence of any of the comorbid medical conditions required for mild OSA.

In a study by Khawaja et al. [16], the authors determined that the initial AHI obtained from the first 2 and 3 h of a full night PSG is a good estimate of the full night AHI across the full spectrum of OSA severity (AHI $\geq$ 5).

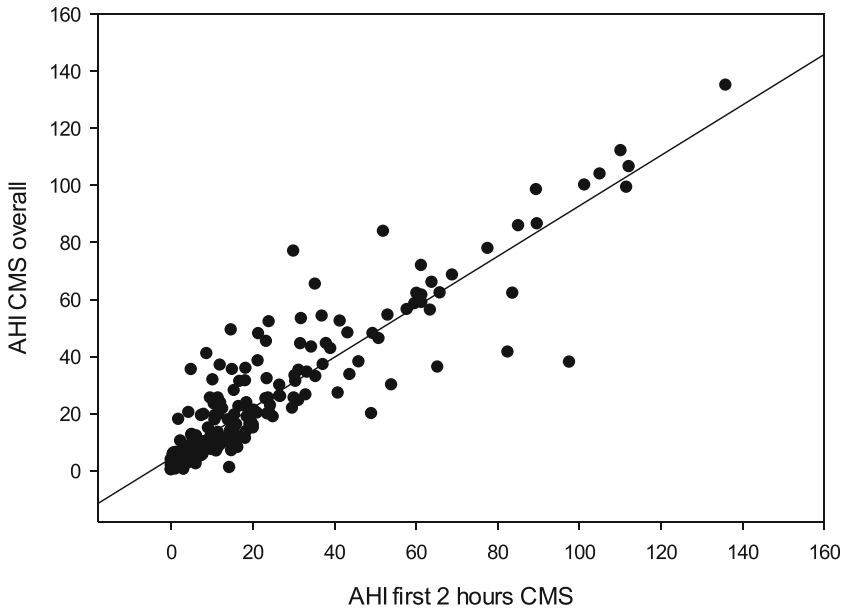

Fig. 2 Linear regression model of the AHI in the first 2 h of sleep vs the overall AHI as per the CMS definition. $Y = a + bX$, where X is the independent variable and Y is the dependent variable. The regression equation is $Y = 4.455 + (0.884 \times X)$; $R^2 = 0.822$; $P < 0.001$. CMS center for Medicare services, AHI apnea-hypopnea index

Table 4 Statistics of 2-h CMS AHI predicting CPAP eligibility

	AHI by CMS ≥ 40 predicting Overall AHI ≥ 15	AHI by CMS ≥ 20 predicting Overall AHI ≥ 15
Sensitivity	34.7%	69.3%
Specificity	100.0%	99.0%
Positive predictive value	100.0%	98.6%
Negative predictive value	60.0%	76.0%

CMS center for Medicare services, *CPAP* continuous positive airway pressure, *AHI* apnea-hypopnea index

They also noted, however, that the criterion of an AHI ≥ 40 (or ≥ 20 in some cases) may be too stringent. Similarly, we found that when the AHI criterion is lowered to an AHI ≥ 20 within the first 2 h of sleep, there is increased sensitivity for an overall AHI ≥ 15, which would qualify a patient for a trial of PAP therapy by most third-party payers, even in the absence of any comorbid medical conditions. In a study by Farghaly and Shaaban [9], the success rate of CPAP titration was evaluated in both SPL and full night titration studies. Ideal criteria for a successful SPL CPAP titration included an AHI ≥ 36.5 h during the diagnostic portion, as well as at least 2.75 h remaining for the titration, which is nearly in line with the AASM's own criteria for performing SPL. Further, they noted that with an AHI less than this, the SPL was more likely to be associated with an unsuccessful CPAP titration.

Comorbid conditions were also examined for their ability to predict an overall AHI ≥ 15. As noted in Table 5, only hypertension was shown to be a significant predictor of AHI ≥ 15. This is consistent with prior studies which have shown the relationship between hypertension and OSA. Indeed, OSA has been shown to be a secondary cause of hypertension for which patients should be evaluated [3]. Other comorbid conditions evaluated did not prove statistically significant predictors; however, this may be in part due to the small numbers of patients with each of these conditions, a recognized limitation of our study. Further, since this is a single center study, the generalizability may be limited.

Table 5 Chi-square analysis performed to assess association of comorbid conditions listed with predicting eligibility for CPAP (overall AHI ≥ 15) by both AASM and CMS criteria

Association of comorbid conditions and prediction of CPAP eligibility		
	P (AASM)	P (CMS)
Chronic lung disease	0.874	0.928
Cardiovascular disease	0.640	0.426
Mood disorder	0.979	0.954
Diabetes	0.668	0.521
Hypertension	0.015*	0.012*

AHI apnea-hypopnea index, *AASM* American academy of sleep medicine, *CMS* center for Medicare services, *CPAP* continuous positive airway pressure

*$p < 0.05$

Conclusion

Our study, using both AASM and CMS criteria for determining AHI, examined the ability of a 2-h AHI of ≥ 40 and ≥ 20 to predict an overall AHI ≥ 15. We determined that using an AHI ≥ 20 is much more sensitive for doing so with very small loss of specificity, highlighting the fact that when ordering SPL, this cutoff may be more useful, especially when considering the approval of CPAP therapy in patients. Additionally, hypertension is a significant comorbid condition predicting an overall AHI ≥ 15.

The findings of the study indicate that when using an AHI of ≥ 40 during the first 2 h of sleep, only about 30% of the patients with and AHI of ≥ 15 will be revealed and that approximately 70% of these patients will need a second study. However, when the requirement is AHI ≥ 20 during the first 2 h, only approximately 23% of patients with AHI ≥ 15 will need a second study. Thus, consideration should be given to reducing the AHI requirement during the first 2 h of sleep to decrease the need for a CPAP titration study.

Compliance with ethical standards

Conflict of interest Author SMS has received research funding from Merck, AASM, and ResMed. 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 the institutional Institutional Review Board of the University of Maryland School of Medicine, and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent This study was a retrospective chart review and approved by our review board, the Institutional Review Board of the University Of Maryland School Of Medicine. Informed consent was waived.

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