CME CREDIT

Use of the sleep laboratory in suspected sleep apnea syndrome: Is one night enough?

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- **BACKGROUND** Sleep-disordered breathing appears to vary widely from night to night in the general population.
- **OBJECTIVE** To determine the difference in accuracy of diagnosing sleep apnea when there are one vs two sleep recordings in a clinical population.
- **METHODS** Fifty patients clinically suspected of having obstructive sleep apnea underwent polysomnography for two nights.
- **RESULTS** The number of episodes of apnea or hypopnea per hour (the apnea-hypopnea index, AHI) on each night was highly correlated ($r = .86$), and there were no significant differences between the two nights in duration of episodes, mean minimal arterial oxygen desaturation, or absolute minimum desaturation. On the first night, 46 patients had an AHI of 5 or more; on the second night 49 did. Similarly, 42 patients had an AHI of 10 or more on the first night; on the second night 46 did. All patients with an AHI of 5 or more on the first night also had an AHI of 5 or more the second night, and only one patient who had an AHI of 10 or more on the first night did not on the second night. In contrast, some nonrespiratory variables improved on the second night.
- **CONCLUSIONS** One night of testing should generally suffice. A second recording might be expected to be positive in half of the small group of patients clinically suspected of having sleep apnea who have a negative first study.

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SLEEP-DISORDERED breathing seems to vary widely from night to night in the general population. For instance, one study found that 43% of elderly normal volunteers had discordant test results for sleep apnea on three consecutive records.[1] In this study, sleep apnea was defined as an apnea-hypopnea index, or AHI (the number of episodes of apnea and hypopnea per hour of sleep) of 5 or more. One implication of such observations is that patients might need more than one night of sleep studies to reliably detect sleep apnea.

In view of the importance of balancing clinical accuracy with allocation of resources in health care, it becomes important to determine whether the substantial night-to-night variability in sleep-disordered breathing that appears to be present in the general population occurs in the self-selected patients who present at a sleep disorders center. To this end, we performed recordings for two nights in 50 consecutive patients who were clinically suspected of having obstructive sleep apnea syndrome, in an effort to assess any possible increase in accuracy which might result.

TABLE 1
SLEEP AND RESPIRATORY MEASURES ON THE FIRST NIGHT OF TESTING IN 46 PATIENTS WHO HAD FIVE OR MORE EPISODES OF APNEA OR HYPOPNEA PER HOUR

Variable	Mean ± SEM
Total recording period, minutes	438.9 ± 4.5
Total sleep time minutes	364.8 ± 8.8
Sleep latency, minutes	10.0 ± 1.3
Rapid-eye-movement (REM) sleep latency, minutes	131.0 ± 10.7
Sleep efficiency, %	73.2 ± 4.1
Number of REM periods	3.0 ± 0.2
Number of REM episodes	8.0 ± 0.9
Stage 1, minutes	35.6 ± 4.6
Stage 2, minutes	253.2 ± 7.8
Stage 3, minutes	8.2 ± 1.5
Stage 4, minutes	10.6 ± 3.9
Total REM sleep, minutes	61.3 ± 5.7
Wake after sleep onset, minutes	63.2 ± 7.3
Period-leg-movement index, no. per hour	1.2 ± 0.5
Number of disordered breathing events in nonREM sleep	264.7 ± 28.0
Number of disordered breathing events in REM sleep	50.4 ± 7.0
Apnea-hypopnea index (AHI) in nonREM sleep, no. per hour	51.4 ± 5.2
AHI in REM sleep, no. per hour	51.1 ± 4.5
AHI for all sleep, no. per hour	51.7 ± 5.0
Average duration of disordered breathing events (apneic and hypopneic) in nonREM sleep, seconds	24.4 ± 0.9
Average duration of disordered breathing events (apneic and hypopneic) in REM sleep, seconds	31.0 ± 1.5
Obstructive apnea in nonREM sleep, %	56.8 ± 4.3
Obstructive apnea in REM sleep, %	71.2 ± 4.8
Obstructive hypopnea in nonREM sleep, %	29.0 ± 4.3
Obstructive hypopnea in REM sleep, %	22.9 ± 4.9
Central apnea in nonREM sleep, %	10.4 ± 3.2
Central apnea in REM sleep, %	6.0 ± 2.1
Central hypopnea in nonREM sleep, %	4.6 ± 1.6
Central hypopnea in REM sleep, %	0.4 ± 0.4
Baseline oxygen saturation in nonREM sleep, %	93.8 ± 0.2
Baseline oxygen saturation in REM sleep, %	92.8 ± 0.5
Mean minimum saturation in nonREM sleep, %	85.7 ± 0.6
Mean minimum saturation in REM sleep, %	79.0 ± 1.4
Absolute minimum saturation in nonREM sleep, %	78.9 ± 1.2
Absolute minimum saturation in REM sleep, %	68.9 ± 2.4

METHODS

The subjects were 42 men and 8 women with a mean age of 50.2 ± 2.3 (standard error of the mean) years who presented to the Sleep Disorders Center of the State University of New York at Stony Brook. The most common reasons for coming to the Center were excessive daytime sleepiness (18 patients), a specific request to be studied for apnea (23 patients), and snoring (two patients). The subjects underwent two consecutive nights of polysomnography using standard techniques,[2] and those who had an AHI of 5 or more on at least one of the nights and in whom obstructive disordered breathing events (apneic and hypopneic) constituted more than 50% of total disordered breathing time were included in the statistical analysis. During rapid-eye-movement (REM) sleep, disordered breathing events constituted 94.1% of total disordered breathing time; in nonREM sleep they constituted 86.8%.

Patients were excluded if they were taking any medications that could suppress respiration, such as long-acting hypnotics or major analgesics. Seven patients were receiving drugs that could potentially affect sleep: three were receiving calcium-channel blockers, one was receiving a beta blocker, and one each was receiving theophylline, lovastatin, and enalapril. A single patient was receiving testosterone. Five patients were receiving psychopharmacologic medications: two were receiving tricyclic antidepressants, one was receiving fluoxetine, and two were receiving lithium carbonate.

Data from the two recordings were assessed for differences across the two nights. We performed several statistical analyses; the most basic assessment was by *t* test for dependent samples. In addition to traditional sleep-staging measures, the following respiratory variables were used: number of episodes of apnea and hypopnea in nonREM and REM sleep and across all sleep; AHI; mean duration of episodes; percentage of time spent in disordered breathing events that was composed of obstructive apnea or hypopnea or central apnea or hypopnea[2]; baseline arterial oxygen saturation in nonREM and REM sleep; mean minimum arterial oxygen saturation in nonREM and REM sleep; and absolute minimum oxygen saturation in nonREM and REM sleep. Finally, we counted the patients who met the criteria for sleep apnea (with AHIs of 5 and 10 as cutoffs) on one or both nights, and periodic leg movement (PLM) disorder (with a PLM index of 5 as the cutoff) on one or both nights. We have defined disordered breathing events (apneic or hypopneic) elsewhere[2]; in general, these events last at least 10 seconds and involve a decrease in arterial oxygen saturation of at least 4%.

RESULTS

Polygraphic diagnosis of sleep apnea based on AHI

On the first night 46 patients had an AHI of 5 or more (*Table 1*), and on the second night 49 patients did. Similarly, on the first night 42 patients had an AHI of 10 or more, and on the second night 46 patients did (*Table 2*). All patients who had an AHI of 5 or more on the first night also had an AHI of 5 or more on the second night; only one patient with an AHI of 10 or more on the first night did not have an AHI of 10 or more on the second night.

Comparison of sleep and ventilatory variables between the two nights

Only two of 21 respiratory variables significantly differed between the two nights by *t* test (*Table 3*). These were the percentage of disordered breathing event time in REM sleep accounted for by obstructive apneas (which decreased on the second night), and baseline arterial oxygen saturation in nonREM sleep (which increased on the second night). The number of disordered breathing events, the AHI, and the minimum arterial oxygen saturation did not change. Sleep efficiency increased on the second night; total sleep time tended to increase and sleep latency tended to decrease ($P < .06$). The patients' subjective estimates of total sleep time significantly increased on the second night, and their estimates of sleep latency significantly decreased.

TABLE 2
SLEEP AND RESPIRATORY VARIABLES IN FOUR PATIENTS WHO HAD 10 OR MORE EPISODES OF APNEA AND HYPOPNEA PER HOUR ON THE SECOND NIGHT, BUT NOT ON THE FIRST NIGHT

Variable	First night (mean ± SEM)	Second night (mean ± SEM)
Total recording period, minutes	448 ± 16	444 ± 8
Total sleep time, minutes	346 ± 57	353 ± 32
Sleep latency, minutes	11 ± 3	5 ± 1
Rapid-eye-movement (REM) latency, minutes	152 ± 70	145 ± 76
Sleep efficiency, %	55 ± 21	79 ± 6
Number of REM periods	3 ± 1	2 ± 1
Number of REM episodes	4 ± 1	1 ± 2
Stage 1, minutes	25 ± 7	24 ± 4
Stage 2, minutes	256 ± 45	278 ± 46
Stage 3, minutes	9 ± 5	7 ± 3
Stage 4, minutes	8 ± 5	14 ± 10
Total REM sleep, minutes	48 ± 22	30 ± 14
Wake after sleep onset, minutes	89 ± 41	85 ± 23
Periodic-leg-movement index, no. per hour	0 ± 0	1 ± 0.1
Disordered breathing events in nonREM sleep	20 ± 11	142 ± 37
Disordered breathing events in REM sleep	0 ± 0	2 ± 2
Apnea-hypopnea index (AHI) in nonREM sleep, no. per hour	4 ± 2	26 ± 5
AHI in REM sleep, no. per hour	0 ± 0	4 ± 3
AHI for all sleep, no. per hour	4 ± 2	25 ± 5
Average duration of disordered breathing events (apneic and hypopneic) in nonREM sleep, seconds	25 ± 0	19 ± 1
Average duration of disordered breathing events (apneic and hypopneic) in REM sleep, seconds	...	34 ± 1
Obstructive apnea in nonREM sleep, %	31 ± 8	44 ± 20
Obstructive apnea in REM sleep, %	...	50 ± 50
Obstructive hypopnea in nonREM sleep, %	61 ± 16	32 ± 18
Obstructive hypopnea in REM sleep, %	...	50 ± 50
Central apnea in nonREM sleep, %	8 ± 8	0 ± 0
Central apnea in REM sleep, %	...	...
Central hypopnea in nonREM sleep, %	...	25 ± 25
Central hypopnea in REM sleep, %	...	...
Baseline oxygen saturation in nonREM sleep, %	94 ± 1	95 ± 1
Baseline oxygen saturation in REM sleep, %	92 ± 2	93 ± 3
Mean minimum oxygen saturation in nonREM sleep, %	90 ± 1	88 ± 1
Mean minimum saturation in REM sleep, %	...	87 ± 4
Absolute minimum saturation in nonREM sleep, %	86 ± 1	83 ± 2
Absolute minimum oxygen saturation in REM sleep, %	...	84 ± 7

Polygraphic diagnosis of periodic leg movement disorder

Four patients had a PLM index of 5 or more on the first night, and two additional patients did on the second night.

TABLE 3
SLEEP AND RESPIRATORY VARIABLES
THAT SIGNIFICANTLY DIFFERED BETWEEN THE TWO NIGHTS (N=50)

Variable	First night (mean ± SEM)	Second night (mean ± SEM)	*P* value*
Total sleep time, minutes	356.6 ± 11.1	375.3 ± 8.6	.06
Sleep latency, minutes	16.8 ± 6.7	8.6 ± 2.5	.06
Rapid-eye-movement (REM) latency, minutes	132.5 ± 10.6	101.1 ± 10.5	.04
Sleep efficiency, %	69.1 ± 4.5	84.9 ± 1.6	.001
Stage 1, minutes	33.4 ± 4.4	21.7 ± 2.0	.01
Stage 2, minutes	249.4 ± 9.1	271.8 ± 8.1	.01
Obstructive apnea time in REM sleep, %	71.2 ± 4.8	55.5 ± 5.7	.01
Baseline oxygen saturation in nonREM sleep, %	93.6 ± 0.2	94.2 ± 0.2	.04
Subjective sleep latency, minutes	29.4 ± 5.3	21.1 ± 3.4	.001
Subjective total sleep, minutes	332.0 ± 19.2	374.4 ± 13.4	.02

*By paired *t* test

DISCUSSION

A number of studies have examined the internight variability of sleep-disordered breathing, primarily in nonclinical populations. In 65 subjects ages 40 to 64, Kripke et al[3] found that the correlation coefficient of desaturation indices (number of desaturations per hour) between two nights was .79. Similarly, we found a correlation coefficient of .86 for the AHI between the two nights in the 49 patients who had an AHI of 5 or more on one of the two nights ($P < .0001$). Bliwise et al,[4] in an ongoing cohort study, examined subjects with a mean age of 74 who had varying degrees of sleep apnea and found that 18% had differences in AHI of at least 10; in our study of a younger group of subjects, 57% did.

Mosko et al[1] tested healthy elderly subjects (mean age 68) for three nights and found that at a cutoff AHI of 5, 43% of the subjects had discordant findings between the different nights; in our two-night study, 8% did. Our study, then, showed substantially less night-to-night variability in respiratory measures than the studies of Kripke et al[3] and Mosko et al.[1] Although a greater percent of our subjects had a difference in AHI of 10 or more, this difference did not usually cross the threshold AHIs of 5 or 10. In fact, such variability as there was had remarkably little effect on diagnosis: only 6% more subjects had an AHI of 5 or more on the second night, and 8% more had an AHI of 10 or more.

Meyer et al[5] approached the question considered here from a slightly different direction. They described 11 patients who presented to a sleep center over the course of 2 years and who were suspected of having sleep apnea but who had negative polysomnograms (an AHI of less than 5). However, on a repeat study, six (54%) had an AHI of 10 or more. When viewed in this manner, our data are similar: eight of our patients had an AHI of less than 10 on the first night, but four of these eight subjects had an AHI of 10 or more on the second night.

Although there was no evidence for a "first-night effect" on respiratory measures (ie, no systematic change between the two nights), a number of objective and subjective measures of sleep improved on the second night. Similarly, Mosko et al[1] found no systematic change in respiratory variables between two nights but did see improvement in polygraphic measures of sleep. Our data confirm this finding and extend it to include improvement in retrospective subjective estimated sleep latency and total sleep.

The causes of night-to-night variability in respiratory measures have not yet been established. Although differences in sleep position are undoubtedly important, at least one study[4] reported that variability occurred with identical gross body position between two nights. We did not systematically record body position in our study, and this variable might alter the results of future work.

The lesser degree of clinically relevant variability in our study compared with other studies might be due to two factors: our patients as a group were substantially younger, and they represented a self-selected sample of persons who sought help at a sleep disorders center and were suspected, on the basis of a screening examination, of having sleep apnea syndrome. These data imply that, due to some combination of these factors, in a clinical setting, one night's

recording detects sleep apnea reasonably well, finding 94% or 87% of cases that would be detected with two studies, depending on whether an AHI of 5 or 10 is used. These data are consistent with the findings of Lee and Giblin,[6] who reported that there was no increase in detection of sleep apnea on a second or third night of recordings in seven patients with chronic obstructive pulmonary disease and AHIs of greater than 5. The implication seems to be that there is no need to routinely test patients suspected of having sleep apnea for two nights. In the relatively small group in whom sleep apnea is strongly suspected but who have negative first studies, a subsequent second night's recording might be expected to be positive in an additional 50%.

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