CHEST

Official publication of the American College of Chest Physicians

Should Children With Suspected Obstructive Sleep Apnea Syndrome And Normal Nap Sleep Studies Have Overnight Sleep Studies? *

Muhammad M. Saeed, Thomas G. Keens, Michael W. Stabile, Joanne Bolokowicz and Sally L. Davidson Ward

Chest 2000;118;360-365
DOI 10.1378/chest.118.2.360

Should Children With Suspected Obstructive Sleep Apnea Syndrome And Normal Nap Sleep Studies Have Overnight Sleep Studies?*

Muhammad M. Saeed, MD; Thomas G. Keens, MD, FCCP; Michael W. Stabile, MS, RPFT; Joanne Bolokowicz, RPFT; and Sally L. Davidson Ward, MD

Study objectives: **Overnight polysomnography (ONP) is the "gold standard" for the diagnosis of sleep-disordered breathing, but it is expensive and time-consuming. Thus, daytime nap studies have been used as screening tests. If the findings of a nap study are normal or mildly abnormal, should ONP be performed? Do specific abnormalities in nap studies predict abnormal findings in ONP? To answer these questions, we conducted this study.**
Design: **Retrospective chart review.**
Setting: **Children's hospital.**
Participants: **One hundred forty-three children with suspected obstructive sleep apnea syndrome secondary to isolated adenotonsillar hypertrophy, who had normal or mildly abnormal nap studies, and underwent ONP.**
Measurements and results: **We compared daytime nap and overnight polysomnograms in 143 children (52 girls; mean [± SD] age, 5.6 ± 3.1 years). Total sleep time was 1 h in daytime nap, and 5.1 ± 1.3 h in ONP. The interval between the two studies was 5.9 ± 4.8 months. The findings of 59% of the nap studies were mildly abnormal, while 66% of overnight studies were abnormal. No individual nap study parameter (including short obstructive apneas, hypopneas, hypoxemia, hypoventilation, snoring, paradoxical breathing, gasping, retractions) had good sensitivity at predicting abnormal overnight polysomnograms, but most had good specificity and positive predictive value.**
Conclusions: **We conclude that individual nap study parameters are not very sensitive in predicting abnormal ONP findings. However, when nap study parameters are abnormal, the chance of obstructive sleep apnea syndrome is high.** ***(CHEST 2000; 118:360–365)***

Key words: children; obstructive sleep apnea; polysomnography; sleep disorders; sleep studies

Abbreviations: ONP = overnight polysomnography; OSAS = obstructive sleep apnea syndrome; $PETCO_2$ = end-tidal carbon dioxide pressure; PSG = polysomnogram; REM = rapid eye movement; SaO_2 = arterial oxygen saturation

Obstructive sleep apnea syndrome (OSAS) due to adenotonsillar hypertrophy is a common pediatric problem, but the diagnosis cannot be established by signs and symptoms alone.[1,2] Overnight polysomnography (ONP) is the "gold standard" to establish a diagnosis, but most sleep laboratories can perform only a few overnight polysomnograms (PSGs) in a 24-h period. With the limited number of pediatric sleep laboratories and trained staff, and an increasing demand for PSGs, it may be difficult to obtain a PSG in a timely manner. To overcome this problem, daytime short (nap) PSGs have been used as a screening test. The daytime nap PSGs are of shorter duration, may require sedation, may not include rapid eye movement (REM) sleep, and may be affected by circadian variation in sleep patterns. In some cases, the diagnosis of OSAS can be established by a nap study, but in some children, findings of a daytime nap study may be normal or inconclusive. In this situation, it is difficult to decide whether an

*From the Division of Pediatric Pulmonology (Dr. Saeed), Mattel Children's Hospital, University of California at Los Angeles School of Medicine; and the Division of Pediatric Pulmonology (Drs. Keen and Davidson Ward, Mr. Stabile, Ms. Bolokowicz), Childrens Hospital Los Angeles, University of Southern California School of Medicine, Los Angeles, CA.
Manuscript received June 22, 1999; revision accepted February 9, 2000.
Correspondence to: Sally L. Davidson Ward, MD, Division of Pediatric Pulmonology, Childrens Hospital Los Angeles, 4650 Sunset Blvd, Mail Stop #83, Los Angeles, CA 90027; e-mail: sward@chla.usc.edu

overnight PSG is required or not. Carroll et al[1] have previously shown that nap PSGs performed with chloral hydrate sedation underestimate the severity of sleep-disordered breathing. They also suggested that if a nap PSG is inconclusive, an overnight PSG should be performed. However, they had a small study population, with a variety of diagnoses, they had only a few children with normal nap studies, and the study was not specifically directed toward obstructive sleep apnea. Thus, it remains unknown which children with adenotonsillar hypertrophy with a normal or mildly abnormal nap study should have an overnight PSG.

Therefore, we evaluated overnight PSGs in 143 children with possible OSAS due to adenotonsillar hypertrophy, who had normal or only mildly abnormal nap studies in order to determine if any parameters in the nap study predict abnormal findings on overnight PSGs.

Materials and Methods

Patients

All patients were referred for polysomnography by their physicians for the evaluation of OSAS secondary to adenotonsillar hypertrophy. The study was confined to children with adenotonsillar hypertrophy because they comprise the majority of children undergoing polysomnography in pediatric sleep laboratories, and they were otherwise healthy, and did not have complicating medical conditions. All the subjects had a nap study with either normal or mildly abnormal findings, and were referred back for an overnight study because of persistent symptoms. Inclusion criteria included the following: (1) age, between 1 year and 18 years; (2) absence of any other significant disease, *eg*, bronchopulmonary dysplasia, chronic lung disease, neuromuscular diseases, craniofacial abnormalities; (3) no therapeutic intervention (*eg*, adenotonsillectomy) between the two studies; and (4) interval between nap and overnight study of < 1 year.

Polysomnography

Nap PSGs were performed during a daytime nap and contained 1 h of sleep time. Chloral hydrate was routinely administered to induce sleep for daytime nap studies unless there were some contraindications to its use. These contraindications include history of food intake within 4 h, evidence of airways obstruction while awake, severe obesity, central respiratory control disorders, neuromuscular diseases, and hypersensitivity to chloral hydrate. The majority of the children received chloral hydrate. An initial dose of 50 mg/kg body weight (maximum dose, 1,000 mg) was administered po. A second dose of 25 mg/kg (maximum, 500 mg) was given if the child failed to sleep after a 30-min observation period. All these patients were examined by a physician on the day of study and cleared for sedation according to the Childrens Hospital Los Angeles sedation guidelines, including nothing po. Overnight PSGs were performed for 8 h, and no sedation was used.

All testing was performed in the Sleep Physiology Laboratory by a pulmonary technician skilled in pediatric polysomnography. PSGs were performed in a quiet, dark room at an ambient temperature of 24°C. The following parameters were measured and recorded continuously by the Healthdyne computerized polysomnography system (Alice III; Respironics; Marietta, GA): (1) chest and abdominal wall motion by uncalibrated respiratory inductance plethysmography; (2) heart rate, by ECG; (3) inspired and end-tidal carbon dioxide pressure (P_{ETCO_2}), sampled at the nose or mouth at a rate of 60 mL/min by mass spectrometry (model 1100 Medical Gas Analyzer; Perkin Elmer; Pomona, CA) or by capnography (model 1000 Capnograph; Nellcor; Hayward, CA); (4) combined oral nasal air flow, sampled with a three-pronged thermistor (Healthdyne Technologies; Marietta, GA) placed at the upper lip; (5) arterial oxygen saturation (Sa_{O_2}), by pulse oximetry (model N 200; Nellcor); (6) oximeter pulse wave form; (7) electro-oculogram; (8) EEG in overnight PSGs; (9) chin electromyogram; (10) actimeter (placed on the hand); and (11) microphone placed over neck to monitor snoring.

Children were also monitored and recorded on videotape, using an infrared video camera. The patients were continuously observed by the technician. Sleep behaviors, respiratory events, and the presence of retractions or gasping were recorded by the technician. EEG was not performed during daytime nap studies, as 1 h of sleep time does not yield sufficient information about sleep stages or EEG arousals.

The following parameters were evaluated: (1) obstructive apnea, defined as complete cessation of air flow at nose and mouth; (2) obstructive hypopnea, defined as a reduction in airflow on thermistor or P_{ETCO_2} tracing to $< 50\%$ of the baseline; (3) apnea hypopnea index (number of obstructive apneas and hypopneas per hour of sleep), and the longest duration of apnea and hypopnea were quantified; (4) hypoventilation ($P_{ETCO_2} > 45$ mm Hg), the highest P_{ETCO_2} and number of episodes of hypoventilation were scored; (5) desaturations ($Sa_{O_2} < 95\%$), Sa_{O_2} nadir, and the number of desaturations; Sa_{O_2} measurements associated with poor pulse tracings were discarded; and (6) presence or absence of snoring, paradoxical breathing, chest wall retractions, and gasping.

Parents of children undergoing polysomnography at our sleep laboratory were requested to answer a questionnaire if snoring, difficulty breathing, and apnea were absent, occasionally present, or always present. All these questionnaires were reviewed.

Only those patients who had normal or mildly abnormal nap studies, were included in the review. Nap studies were classified as follows: (1) normal, defined as no obstructive apnea and hypopnea index ≤ 1 event/h, Sa_{O_2} nadir $> 95\%$, and highest $P_{ETCO_2} \leq 45$ mm Hg; or (2) mildly abnormal, defined as obstructive apnea-hypopnea index, 1 to 2 events/h; Sa_{O_2} nadir 90 to 94%, or highest P_{ETCO_2}, 46 to 49 mm Hg.

ONP findings were classified as normal or abnormal based on criteria previously established.[3] Abnormal studies were further classified as follows: (1) mildly abnormal, with obstructive apnea hypopnea index, 1 to 2 events/h; Sa_{O_2} nadir of 90 to 94%; or highest P_{ETCO_2}, 46 to 49 mm Hg; (2) moderately abnormal, with obstructive apnea hypopnea index, 3 to 5 events/h; Sa_{O_2} nadir of 85 to 89%; or highest P_{ETCO_2}, 50 to 54 mm Hg; or (3) severely abnormal, with obstructive apnea hypopnea index > 5 events/h, Sa_{O_2} nadir of $\leq 84\%$; or highest $P_{ETCO_2} \geq 55$ mm Hg.

Statistical Methods

All data are expressed as mean ± SD, where appropriate. Comparison was performed by χ^2 analysis (subjects with obstructive apnea, obstructive hypopnea, obstructive hypoventilation, hypoxemia, snoring, paradoxical breathing, intercostal retractions, and gasping) or by Student's paired t test (longest obstructive apnea, longest obstructive hypopnea, lowest Sa_{O_2}, and highest P_{ETCO_2}). The sensitivities (true-positives/[true-positives + false-negatives]), specificities (true-negatives/[true-

Table 1—*Abnormalities Found in Nap Studies

Variables	OSA	OH	Hypox	Hypovent	Snoring	PB	Retr	Gasp
Normal nap (n = 59)	0	4 (7)	0	0	25 (42)	12 (20)	1 (2)	3 (5)
Mildly abnormal nap (n = 84)	29 (34)	49 (58)	32 (38)	30 (36)	52 (62)	39 (46)	1 (1)	8 (9)

*Data are presented as No. (%). OSA = obstructive sleep apnea; OH = obstructive hypopnea; Hypox = hypoxemia; Hypovent = hypoventilation; PB = paradoxical breathing; Retr = retractions; Gasp = gasping.

negatives + false-positives]), positive predictive values (true-positives/[true-positives + false-positives]), and negative predictive values (true-negative/[true-negatives + false-negatives]) for different parameters were calculated. Sensitivity was defined as the proportion of diseased persons the test classified as positive. Specificity was defined as the proportion of nondiseased persons the test classified as negative. Positive predictive value was defined as the proportion of positive tests that identified the diseased persons. Negative predictive value was defined as the proportion of the negative tests that correctly identified the nondiseased persons.

Results

One hundred forty-three children had normal or mildly abnormal findings on nap PSGs from 1991 to 1998. Their mean age was 5.6 ± 3.1 years, and 52 were girls (36%). The mean interval between nap and overnight PSGs was 5.9 ± 4.8 months. Total sleep time during nap studies was 1 h, while mean sleep time during the overnight studies was 5.1 ± 1.3 h.

One hundred thirty-eight patients (96%) were sedated with chloral hydrate during nap studies. The remaining patients did not receive chloral hydrate because of spontaneous sleep or a history of food intake within 4 h prior to study. The administration of chloral hydrate was not associated with any side effects. No patient received sedation for overnight studies.

Fifty-nine of the nap study findings were normal (41%). Among these subjects, none had obstructive apnea, hypoxemia, or hypoventilation. However, 4 subjects (7%) had brief (< 6 s) obstructive hypopnea, 25 subjects (42%) had snoring, 12 subjects (20%) had paradoxical breathing, 1 subject (2%) had chest retractions, and 3 subjects (5%) were noticed to have gasping. Among 84 children who had mildly abnormal findings on nap studies, 29 children (34%) had one or more obstructive sleep apnea, 49 children (58%) had one or more obstructive hypopnea, 32 children (38%) had hypoxemia, 30 children (36%) had hypoventilation, 52 children (62%) had snoring, 39 children (46%) were noticed to have paradoxical breathing, 1 child (1%) had chest retractions, and 8 children (9%) had gasping. These abnormalities are summarized in Table 1. Among overnight sleep studies, 95 findings (66%) were normal. The children with mildly abnormal nap studies were at significantly higher risk of having an abnormal overnight sleep study ($p < 0.0001$), when compared to those who had normal nap studies (Table 2). The major difference between normal and abnormal nap studies was in the severely abnormal overnight studies (7% in children with normal nap findings vs 37% in children with mildly abnormal nap study; $p = 0.0002$; Table 3). There were 19 children (13%) who had a mildly abnormal nap study but a normal overnight study.

Significantly more children demonstrated obstructive apneas, hypopneas, hypoxemia, snoring, paradoxical breathing, and gasping during overnight sleep studies (Table 4). The durations of longest apnea and hypopnea was also longer in overnight studies. There was no significant difference in the number of children who demonstrated hypoventilation and retractions during nap and overnight sleep studies.

No individual nap parameter had both good sensitivity and specificity at predicting abnormal overnight studies, but most had good specificity and positive predictive value (Table 5). The presence of snoring during a nap study was the most sensitive (86%) parameter predicting an abnormal overnight

Table 2—*Distribution of Nap and Overnight PSGs

Variables	Normal ONP	Abnormal ONP	p Value
Normal nap (n = 59)	29 (49)	30 (51)	0.8
Mildly abnormal nap (n = 84)	19 (23)	65 (77)	< 0.0001

*Data are presented as No. (%).

Table 3—*Stratification of Abnormal Overnight PSGs in Relation to the Nap Study Results

Variables	Mildly Abnormal ONP	Moderately Abnormal ONP	Severely Abnormal ONP
Normal nap	10 (17)	15 (25)	5 (8)
Mildly abnormal nap	13 (15)	21 (25)	31 (37)
p value	0.4	0.15	0.008

*Data are presented as No. (%).

Table 4—*Comparison of Abnormalities During Nap and Overnight PSGs

Abnormalities	Nap	ONP	p Value
Subjects with abnormal studies, No. (%)	84 (59)	95 (66)	0.22
Subjects with obstructive apnea, No. (%)	29 (20)	95 (66)	< 0.0001
Longest obstructive apnea, s	11.4 ± 4.6	19.9 ± 11.6	0.0004
Subjects with obstructive hypopnea, No. (%)	53 (37)	106 (74)	< 0.0001
Longest obstructive hypopnea, s	12.3 ± 8.2	29.9 ± 37.8	0.0026
Subjects with hypoxemia (SaO_2 < 95%), No. (%)	32 (22)	82 (57)	< 0.0001
Lowest SaO_2 (%)	91.4 ± 3.8	85.9 ± 11.9	0.0001
Subjects with obstructive hypoventilation ($PETCO_2$ > 45 mm Hg), No. (%)	30 (21)	42 (30)	0.13
Highest $PETCO_2$, mm Hg	48.7 ± 2.2	51.5 ± 3.6	0.04
Subjects with snoring, No. (%)	77 (54)	95 (66)	< 0.0001
Subjects with paradoxical breathing, No. (%)	52 (36)	103 (72)	< 0.0001
Subjects with gasping, No. (%)	2 (1.4)	28 (20)	< 0.0001
Subjects with intercostal retractions, No. (%)	11 (8)	18 (13)	0.23

*Data are presented as mean ± SD unless otherwise indicated.

study, but it was also the least specific (48%). The presence of a mildly abnormal nap study had moderate sensitivity (69%) and specificity (60%) in predicting an abnormal overnight study. Presence of any obstructive apnea, hypopnea, hypoxemia, or hypoventilation in a nap study was moderately specific and had good positive predictive values, but had lower sensitivities. The presence of gasping and retractions was 100% specific with excellent positive predictive value, but their sensitivity was also variable.

The questionnaires were available for 133 patients. The parent's response to the questionnaire is summarized in Table 6. Significantly more parents of children with OSAS noticed that their children always had difficulty breathing and or apnea during sleep. Sensitivity, specificity, positive predictive value, and negative predictive values for each symptom are shown in Table 7. The always presence of difficulty breathing and snoring had very good sensitivities but low specificities. History of presence of apnea during sleep was neither sensitive nor very specific in predicting OSAS.

Discussion

We found that no individual nap study parameter was very sensitive in predicting the presence of obstructive sleep apnea in an overnight sleep study. However, many of them had good specificity and positive predictive values. We also found that if nap studies are even mildly abnormal, there is a high chance of having an abnormal overnight sleep study. This study also suggests that nap studies underestimate the abnormalities detected by ONP, even when children were sedated with chloral hydrate. Since REM sleep is infrequently seen in daytime nap studies, the higher incidence of sleep-disordered breathing seen in overnight studies may be due, in part, to the increased REM sleep.

There have been several studies in adults that have correlated short daytime (nap) or partial-night studies with overnight studies. However, none of those studies evaluated individual parameters in the nap studies. Sanders et al[4] compared the first half of an overnight sleep study to a whole night study in 48

Table 5—*Sensitivity, Specificity, Positive Predictive, and Negative Predictive Values of Nap Parameters*

Parameters	Sensitivity, %	Specificity, %	Positive Predictive Value, %	Negative Predictive Value, %
Abnormal nap	69	60	77	49
OSA	23	85	76	36
Hypopnea	40	69	72	37
Hypoxemia	26	85	78	37
Hypoventilation	25	88	80	37
Snoring	86	48	71	69
Paradoxical breathing	69	68	83	47
Gasping	20	100	100	11
Retractions	58	100	100	11

Table 6—*Response to Questionnaire

Symptoms	Presence	Normal ONP (n = 46)	Abnormal ONP (n = 87)	p Value
Snoring	Never	5 (11)	4 (5)	0.31
	Sometimes	9 (20)	14 (16)	0.79
	Always	32 (69)	69 (79)	0.29
Difficulty breathing	Never	8 (17)	6 (7)	0.11
	Sometimes	22 (48)	26 (30)	0.06
	Always	16 (35)	55 (63)	0.003
Stopped breathing	Never	19 (41)	24 (27)	0.15
	Sometimes	22 (48)	34 (39)	0.43
	Always	5 (11)	29 (34)	0.009

*Data are presented as No. (%).

Table 7—*Sensitivity, Specificity, Positive Predictive, and Negative Predictive Values of Symptoms From Questionnaire*

Symptoms	Presence	Sensitivity, %	Specificity, %	Positive Predictive Value, %	Negative Predictive Value, %
Snoring	Sometimes	78	36	61	55
	Always	95	13	68	55
Difficulty breathing	Sometimes	81	30	54	57
	Always	90	33	77	57
Stopped breathing	Sometimes	59	46	61	44
	Always	55	79	85	44

adult patients. They found that apnea index, apnea hypopnea index, and desaturation event frequency had high sensitivities (87.9 to 93%), positive predictive values (93.6 to 100%), and specificities (86.7 to 100%). Mizuma and colleagues[5] compared daytime (3 h) and nocturnal polysomnography indexes of sleep, apnea index, and Sa_{O_2} in 30 adult patients.[5] They found no significant differences among the indexes, and there was a significant positive correlation between nocturnal and daytime polysomnography in all variables related to sleep apnea. Series and colleagues[6] compared daytime and nocturnal PSGs in adults, and demonstrated that daytime sleep recordings were accurate in the diagnosis of sleep apnea syndrome, and of the types of apneas, but they were not reliable for the evaluation of sleep architecture. Carmona et al[7] compared PSGs recorded over the first 3 h of nocturnal sleep to the entire night PSGs in patients suspected of having OSAS. In their study, 3-h nocturnal sleep studies had a sensitivity of 84% and specificity of 100%. They concluded that if polysomnography during first part of nocturnal sleep is negative, it should be continued throughout the entire night. Roberts and Hooper[8] reported similar results when comparing first 4 h of nocturnal sleep studies to full-night studies. They found that 4-h sleep studies were 100% sensitive and 97% specific in identifying sleep apnea syndrome. The studies by Silvestri et al[9] and Cordero et al[10] compared daytime PSGs to overnight studies and found that daytime sleep studies had good sensitivity and specificity, but concluded that ONP should be performed in the patients with presumed OSAS and negative daytime PSGs. The only study in the pediatric population, done by Marcus et al,[3] showed that nap studies significantly underestimated the abnormalities detected by ONP. Our findings are consistent with this latter study. However, their study did not evaluate whether the individual nap study parameters might be able to predict the presence of OSAS in an overnight sleep study.

The use of chloral hydrate was not associated with any side effects in our study. Thus, it was a safe medication when used to induce sleep in daytime studies in the uncomplicated patients in our study. It did not seem to cause sleep-disordered breathing. However, chloral hydrate should be used cautiously in patients who might be at high risk of upper airway obstruction (such as infants < 3 months old, obese children, children with evidence of upper airway obstruction while awake, and patients with craniofacial anomalies), as chloral hydrate may precipitate upper airways obstruction.[11]

We also found that a parent's report about the presence of snoring, difficulty breathing, and apnea was neither very sensitive nor specific in predicting the presence of OSAS. However, a parent's report about their children always having snoring and or difficulty breathing during sleep was much more sensitive in predicting the presence of OSAS. All these findings suggest that the diagnosis of OSAS cannot be accomplished by the history of these three symptoms alone.[1,2] In addition, it is possible that some of the children who snore but had normal findings in ONP may have upper airway resistance syndrome.

In pediatric sleep laboratories, nap studies are often used as a relatively inexpensive screening test. Since our study shows that nap studies often need to be confirmed by an overnight PSG, the potential cost advantages of nap studies may evaporate. Overnight PSGs have been shown to be a cost-effective diagnostic tool in adults.[12] Our results suggest that the same may be true for children.

We conclude that individual nap parameters are not very sensitive in predicting an abnormal overnight PSG. Hence, if a nap study is normal or only mildly abnormal, and the clinical suspicion is high, an overnight PSG should be performed to confirm the diagnosis of OSAS. The children who have even mildly abnormal nap studies tend to have more severe abnormalities on overnight PSGs. We speculate that in children with suspected OSAS secondary to adenotonsillar hypertrophy, any nap study with normal or mildly abnormal findings should always be confirmed by an overnight PSG.

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