Accuracy of clinical evaluation in pediatric obstructive sleep apnea

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Eighty-two children underwent polysomnography (PSG) for symptoms suggestive of obstructive sleep apnea (OSA). Symptoms reported included snoring, witnessed apneic episodes, daytime somnolence, mouth breathing, and enuresis. Tonsillar size, nasal airway patency, and percentile weight were recorded. OSA was diagnosed on PSG when obstructive events were noted and apnea + hypopnea index was five or more per hour. The overall predictive accuracy of clinical suspicion of OSA was 25 (30%) of 82. Predictive accuracies (as a percentage of those with symptoms/signs who have OSA) and prevalences (as a percentage of those with OSA who have the symptom/sign), respectively, were for moderate snoring 29% (12 of 41), 48%; loud snoring 31% (11 of 35), 44%; witnessed apneas 32% (22 of 69), 88%; enuresis 46% (11 of 24), 44%; 2+ tonsillar size 37% (21 of 57), 84%; 3+ tonsillar size 33% (3 of 9), 12%; 90th percentile weight or greater 26% (7 of 27), 28%; 10th percentile weight or less 33% (5 of 15), 20%. Multiple regression analysis did not reveal a significant association between clinical parameters and the presence of OSA as defined by PSG. (Otolaryngol Head Neck Surg 1998;118:69-73.)

Complications of obstructive sleep apnea (OSA) in children include pulmonary hypertension and cor pulmonale,[1,2] failure to thrive,[3,4] growth retardation,[4] developmental delay,[3] behavioral disturbances,[3] poor school performance,[5] neurologic insult,[3] and enuresis.[6,7] The true prevalence of OSA in children is unknown; the lower limit of prevalence has been estimated to be 2.9%.[8] Reports of the accuracy of clinical evaluation in predicting OSA in children as defined by polysomnography (PSG) are few and vary between 37% and 51%.[9-12] These studies are limited by differing criteria for OSA and small samples of patients.[10,12]

Tonsillectomy and adenoidectomy (T&A) are increasingly performed for indications of upper airway obstruction,[13] often based on clinical criteria alone. In children with PSG-proven OSA who undergo T&A, resolution of OSA after surgery, as determined by repeated PSG, ranges from 78% to 100%,[10-12,14] but compliance with follow-up PSG is often poor.[3,10,12] This study examined the predictive accuracy of clinical evaluation for OSA and outcome after T&A in a series of children undergoing PSG.

METHODS AND MATERIAL

Eighty-two consecutive children referred for overnight polysomnography because of symptoms suggestive of OSA were studied retrospectively. Mean age was 6.7 years, with a range of 18 months to 15 years. There were 49 boys and 33 girls. Symptoms that were elicited from parents or legal guardians consisted of snoring (with subjective scoring of none, mild, moderate, and loud); witnessed apneas (with estimated maximal duration and frequency); nocturnal choking; frequent awakenings or arousals; mouth breathing during sleep; and enuresis. The parent was encouraged to observe the child during sleep to clarify symptom condition when necessary.

Tonsillar size was graded as 1+, medial borders of tonsils lateral to or extending to the pillars; 2+, medial borders of tonsils lateral to or extending to the lateral uvular margins; 3+, medial borders of tonsils medial to the lateral uvular margins (includes “kissing” tonsils, which meet in the midline). Grading was performed with the oropharynx relaxed, as gagging tended to displace the tonsils medially. The presence of nasal airway obstruction was noted; complete obstruction was confirmed by the absence of examination mirror fogging

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Table 1. Clinical parameters and OSA

Symptom/Sign	Predictive accuracy (%)	Prevalence (%)
Snoring		
Moderate	29 (12/41)	48
Loud	31 (11/35)	44
Witnessed apneas	32 (22/69)	88
Daytime somnolence	33 (5/15)	20
Mouth breathing	30 (9/30)	36
Enuresis	46 (11/24)	44
Tonsil size		
1+	0 (0/12)	0
2+	37 (22/59)	88
3+	30 (3/10)	12
Weight		
≥90%tile	26 (7/27)	28
<90%tile ≤ 10%tile	33 (13/40)	52
≤10%tile	33 (5/15)	20

when held under the nose. Percentile weight was recorded.

PSG was performed overnight for 6 to 7 hours by a trained technologist. The following parameters were measured: four-channel electroencephalography with bilateral central and occipital leads; electrooculography to measure vertical and horizontal eye movements; electromyography with submental electrodes; electrocardiography; airflow recording through nose and mouth by a thermocouple; thoracic and abdominal effort by plethysmography; oxygen saturation through pulse oximetry; and tracheal sound recording by using a microphone secured to the neck. Besides the polysomnographic recordings, videotaping with sound recording was performed throughout the night. Snoring intensity was graded as mild, less than 70 dB; moderate, 70 to 80 dB; loud, more than 80 dB as determined by a decibel meter at a distance of 10 cm. The PSG was interpreted by one of us (A.W.), a Diplomate of the American Board of Sleep Medicine with 17 years of experience. Sleep latency, sleep efficiency, sleep stages, oxygen saturation, arousals, awakenings, and numbers of apneas and hypopneas were quantified.

Respiratory events were defined as follows: central apnea, lack of respiratory effort and airflow for at least 10 seconds; obstructive apnea, presence of paradoxic respiratory effort with lack of airflow for at least 10 seconds; hypopnea (obstructive), presence of paradoxic respiratory effort with reduction of airflow to less than 50% of baseline, producing arousal or oxyhemoglobin desaturation of 4% or more; hypopnea (central), reduction of synchronous respiratory effort with reduction of airflow to less than 50% of baseline; and mixed apnea, central apnea followed by obstructive apnea.

Table 2. Objective snoring loudness and OSA

Snoring intensity	Predictive accuracy (%)
Mild (<70 dB)	19 (3/16)
Moderate (70-80 dB)	33 (5/15)
Loud (>80 dB)	60 (6/10)

Respiratory events were classified and their number, frequency, and duration recorded, along with concomitant lowest oxyhemoglobin saturation and cardiac arrhythmias. Respiratory distress index (RDI) was defined as the average number of apneas plus hypopneas per hour of sleep. OSA was defined as an RDI of 5 or greater with evidence of obstructive respiratory events. The latter qualification was added after a patient considered not to have OSA had a PSG showing an RDI of eight events/hour, with all events being central apneas (51 total) and a lowest oxyhemoglobin saturation of 94%.

Adenotonsillectomy was recommended by an otolaryngologist (R.W.) after reviewing individual histories, physical findings, and PSG results. All patients with OSA were observed postoperatively in a pediatric intensive care unit with electrocardiographic and pulse oximetry monitoring. Follow-up PSG was scheduled at least 5 weeks after surgery.

Multiple logistic regression was used by a biostatistician (D.H.) to determine whether clinical characteristics, alone or in combination, can accurately predict the existence of OSA as defined by PSG criteria. A *t* test was used to compare mean values between groups.

RESULTS

Overall predictive accuracy was 30%, with 25 of 82 children shown to have OSA by PSG. One patient with OSA had mandibular hypoplasia and Treacher-Collins syndrome; no other cases with OSA demonstrated craniofacial deformities. Predictive accuracies (as a percentage of those with a symptom/sign who have OSA) and prevalences (as a percentage of those with OSA who have the symptom/sign) of the more common clinical parameters are shown in Table 1. All children referred for PSG had either snoring (76 of 82) or witnessed apneas (69 of 82) but not necessarily both. Witnessed apneas by the parent(s) or legal guardian correctly characterized OSA by PSG in only 32% of cases. The symptom with highest predictive accuracy was enuresis at 46%. No child with small tonsils was shown to have OSA. On the other hand, large tonsils did not predict OSA more frequently than moderate-sized tonsils. Tonsillar size was not graded in one

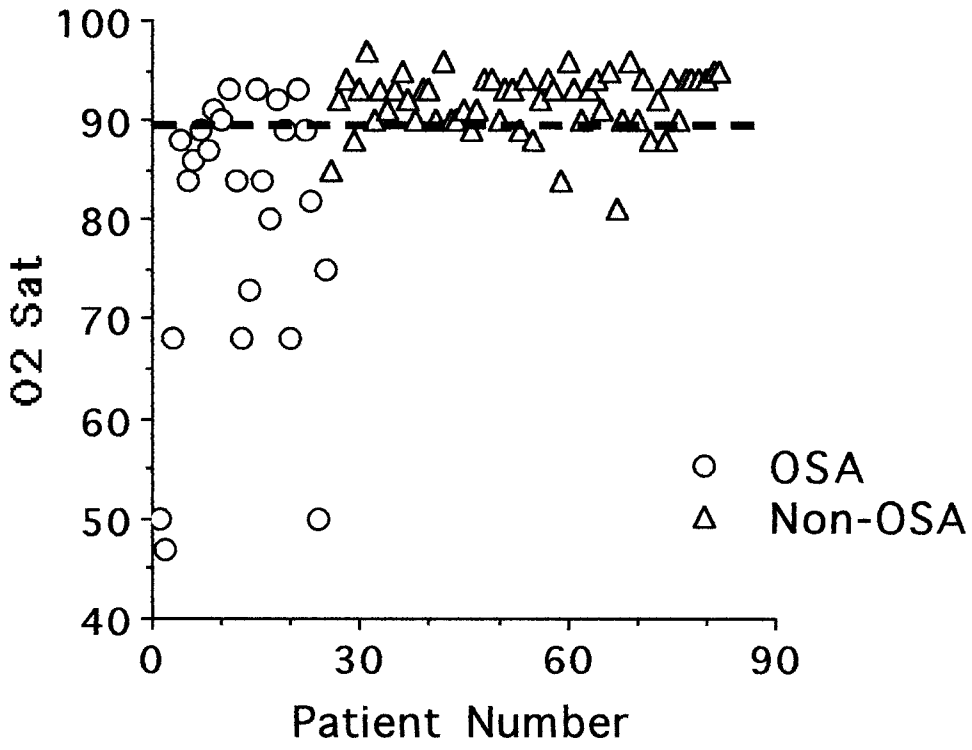

Fig. 1. Lowest oxyhemoglobin saturations in patients with and without OSA.

patient who had previously undergone T&A and did not have OSA. Neither obesity (>90th percentile weight) nor low weight for age (≤10th percentile) predicted OSA better than having a weight between those two extremes. Predictive accuracy of graded snoring loudness during PSG, performed in 41 of 82 patients during the latter portion of the study, is presented in Table 2. The highest predictive accuracy of the parameters studied, at 60%, is found with snoring intensity greater than 80 dB. When multiple logistic regression analysis was performed, no significant association was found between any one or a combination of clinical parameters including age and gender, which might be used to diagnose upper airway obstruction, and OSA as defined by PSG.

Table 3 displays mean age and PSG measurements in those with and without OSA. A significant difference ($p < 0.0001$) in RDI between the two groups was found by unpaired *t* testing. Figure 1 is a scattergram depicting individual lowest oxyhemoglobin saturation in the two groups. Of interest are the three patients without OSA whose saturations decreased to 81% to 85%, to be discussed subsequently.

Twenty-two of 25 patients with OSA underwent T&A (with uvulopalatopharyngoplasty [UPPP] in 2). The patients' legal guardians refused surgery and continuous positive airway pressure (CPAP) in the remaining 3 cases. The 2 children undergoing UPPP each had redundant uvula and soft palate as well as RDIs of 18 and 25/hour, with lowest oxyhemoglobin saturations of less than 70%. Of the 57 patients without OSA, 23 underwent T&A for recurrent adenotonsillitis. Eleven of the 22 operative cases for OSA received a subsequent PSG, with results shown in Table 4. There was a significant ($p < 0.02$) improvement in mean RDI postoperatively by paired *t* testing. More important, no individual follow-up RDI reached 5/hour, and only two (85% and 89%) had lowest oxyhemoglobin saturations of less than 90%.

Three patients mentioned had RDIs less than 5 but desaturated nonetheless. They underwent T&A for infectious indications and had repeated PSGs (Table 5). Oxyhemoglobin saturations stayed at 90% or more in all three cases after surgery. In one patient, the RDI increased from 3.5/hour to 5.4/hour, but the latter score consisted entirely of central apneic episodes.

Table 3. Characteristics of patients with and without OSA

Mean	OSA	Non-OSA
Age	5.9 yr	6.9 yr
RDI	18.4/hr	2.7/hr
Low O_2 Sat	79%	92%
ΔO_2 Sat	–12%	–3.5%

Table 4. PSG data in 11 OSA patients before and after T&A

Mean	Pre-Op	Post-Op
RDI	31.5/hr	1.9/hr
Low O_2 Sat	75%	91%
ΔO_2 Sat	–14%	–3.8%

Table 5. PSG data in three patients without OSA before and after T&A

	RDI (events/hr)		Low O2 Sat (%)		Δ O2 Sat (%)	
Patient	Pre	Post	Pre	Post	Pre	Post
1	3.5	0.9	85	90	–9	–6
2	3.5	5.4	84	95	–13	–2
3	0.8	0.4	81	94	–11	–3

DISCUSSION

Our results concur with others[9-11] in showing the lack of predictive value of symptoms and signs attributable to OSA in children, when determining the presence of OSA by PSG. As was found by Suen et al.,[11] multiple regression analysis failed to show an association between clinical variables alone or in combination and OSA; overall predictive accuracy was 51% in their series of 69 children. Goldstein et al.[10] found no statistical correlation between clinical predictive scoring (which used findings from history, physical examination, and audiotape of breathing while asleep) and the existence of OSA by PSG in 30 children; the predictive value of those thought to have "definite" OSA was 56% and was 33% for those having "possible" OSA by clinical features. Similarly, Leach et al.[9] discovered no significant differences in age, sex, or symptoms in 34 children with OSA compared with 54 with normal or non-OSA PSG findings (for a predictive accuracy of 39%). Brouillette[15] showed significantly fewer OSA-related symptoms in 45 control children (none had PSG done) as opposed to 23 PSG-proven patients with OSA. An OSA scoring system was developed from observed apneas, difficulty breathing, and snoring. The predictive value of this scoring method for 23 subsequent children was 65% when including those 5 patients with "borderline" OSA. Omitting the latter patients, the predictive accuracy was 56%.

Comparison of studies is complicated by the differing PSG criteria used to define OSA by the various investigators. Whereas an RDI of greater than 5 events per hour was used by some,[6,7,11] others used an RDI of more than 15/hour or at least 25/hour for at least one hour.[10] OSA in children also has been defined as an apnea index of more than one per hour, or oxyhemoglobin desaturation to less than 92%, or peak nasal end-tidal P_{CO_2} greater than 53 mm Hg, or hypoventilation (defined as nasal end-tidal P_{CO_2} > 45 mm Hg) duration greater than 60%.[4] Alternatively, transcutaneous P_{O_2} less than 50 mm Hg or nasal end-tidal P_{CO_2} greater than 45 mm Hg, with effects attributable to OSA (e.g., failure to thrive, cor pulmonale, neurobehavioral disturbances) have been used to diagnose children with OSA.[15] Some authors prefer to compare the number of oxyhemoglobin desaturations of greater than 4% per hour between patients and control subjects to establish criteria for childhood OSA.[12,14]

Interestingly, none of the 12 children in this study with small, 1+ tonsils had OSA. Neither obesity nor low weight ("failure to thrive") were predictive of OSA. The highest predictive score of 60% was obtained by grading snoring loudness during PSG by using a decibel meter. Potsic[16] used a filtered neck-microphone signal to show good correlation between disordered breathing patterns and a 2-hour PSG in 18 children, with only 4 patients having more than five apneas/hour (hypopneas were not addressed).

The three children with normal RDI scores and desaturations that were improved by T&A may have had a variant of obstructive sleep disorder called "upper airway resistance syndrome."[17] However, as this diagnosis requires the presence of increased peak inspiratory esophageal pressure measurements (not performed in this study), our laboratory is beginning to monitor this parameter as well.

The encouraging results of treatment with T&A for OSA in this series have been noted in other studies[3,10,11,14] and are attributable in part to the presence of only one child with congenital craniofacial anomaly. Although results are best monitored by objective PSG criteria, the rate of postoperative PSG testing is often low, from 43% to 64%.[3,10,12] In the series with the high-

est reported postoperative PSG study compliance rate of 87%, the cure rate for T&A used to treat OSA in children was 85%.[11]

By using existing regional fee schedules for T&A with postoperative monitoring and PSG, calculated expenditures for 100 patients suspected of OSA treated with T&A in all 100 would be $360,000 compared with $355,000 if all were given preoperative PSG, and 30% underwent T&A and postoperative PSG. The relative cost of these approaches is dependent on the actual cost of T&A and postoperative monitoring, PSG, percentage shown to have OSA by PSG who need treatment and repeated PSG. This type of analysis does not consider other accepted indications for tonsillectomy or adenoidectomy or both, such as recurrent infection, nasal airway obstruction, dysphagia, and recurrent otitis media with effusion, but follows the method of others[11] in evaluating the cost-effectiveness of management of OSA after PSG, which becomes an issue when insurers deny coverage for PSG or balk at approving PSG testing.

The real benefit of PSG testing is the accurate diagnosis of OSA in children compared with that based on clinical evidence alone, resulting in avoidance of unnecessary surgery if no other indications for T&A are present. Among our current objectives are the reduction of PSG cost while implementing new techniques to improve accuracy of testing and diagnose subtle obstructive sleep disturbances, such as upper airway resistance syndrome, gastroesophageal reflux, and OSA-related enuresis.

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REFERENCES

1. Menashe VD, Farrehi C, Miller M. Hypoventilation and cor pulmonale due to chronic airway obstruction. J Pediatr 1965;67: 198-203.
2. Sofer S, Weinhouse E, Tal A, et al. Cor pulmonale due to adenoidal or tonsillar hypertrophy or both in children. Chest 1988; 93:119-22.
3. Brouillette RT, Fernbach SK, Hunt CE. Obstructive sleep apnea in infants and children. J Pediatr 1982;100:31-40.
4. Marcus CL, Carroll JL, Koerner CB, et al. Determinants of growth in children with the obstructive sleep apnea syndrome. J Pediatr 1994;125:556-62.
5. Guilleminault C, Stroohe R. Chronic snoring and obstructive sleep apnea syndrome in children. Lung 1990;168:912-9.
6. Guilleminault C, Korobkin R, Winkle R. A review of 50 children with obstructive sleep apnea syndrome. Lung 1981;159:275-87.
7. Want RC, Cordemark J. Effects of sleep apnea treatment upon enuresis in children. Surg Forum 1994;45:643-4.
8. Gislason T, Benediktsdottir B. Snoring, apneic episodes, and nocturnal hypoxemia among children 6 months to 6 years old. Chest 1995;1077(4):963-6.
9. Leach J, Olson J, Hermann J, Manning S. Polysomnographic and clinical findings in children with obstructive sleep apnea. Arch Otolaryngol Head Neck Surg 1992;118:741-4.
10. Goldstein NA, Sculerati N, Walsleben JA, et al. Clinical diagnosis of pediatric obstructive sleep apnea validated by polysomnography. Otolaryngol Head Neck Surg 1994;111(5):611-7.
11. Suen JS, Arnold JE, Brooks LJ. Adenotonsillectomy for treatment of obstructive sleep apnea in children. Arch Otolaryngol Head Neck Surg 1995;121:525-30.
12. DeBenedetto M, Cuda D, Leante M. Obstructive sleep apnea syndrome and A&T surgery. In: Galioto GB, editor. Tonsils: a clinically oriented update. Adv Otorhinolaryngol. Basel: Karger; 1992. p. 271-5.
13. Rosenfeld RM, Green RP. Tonsillectomy and adenoidectomy: changing trends. Ann Otol Rhinol Laryngol 1990;99:187-91.
14. Stradling JR, Thomas G, Warley ARH, et al. Effect of adenotonsillectomy on nocturnal hypoxaemia, sleep disturbance, and symptoms in snoring children. Lancet 1990;335:249-53.
15. Brouillette R, Hanson D, David R, et al. A diagnostic approach to suspected obstructive sleep apnea in children. J Pediatr 1984; 105:10-4.
16. Potsic WP. Comparison of polysomnography and sonography for assessing regularity of respiration during sleep in adenotonsillar hypertrophy. Laryngoscope 1987;97:1430-7.
17. Guilleminault C, Stoohs R, Clerk A, et al. A cause of excessive daytime sleepiness: the upper airway resistance syndrome. Chest 1993;104:781-7.