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Age specific differences in pediatric obstructive sleep apnea☆

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ABSTRACT

Background: Some have suggested that younger children have a more severe form of obstructive sleep apnea than older children and therefore are at a higher risk for respiratory compromise after tonsillectomy and adenoidectomy. However, at present there are few studies that have identified any significant correlation between age and severity of obstructive sleep apnea.
Objective: To determine if age specific differences in obstructive sleep apnea are present in children.
Design: Retrospective chart review.
Setting: Tertiary care children's hospital.
Patients: The records of children (1–18 years of age) with obstructive sleep apnea diagnosed by overnight polysomnography between January 1998 and January 2001 were reviewed. Children included in the study also had evidence of adenotonsillar hypertrophy and had no other co-existing medical problems.
Main outcome measures: Overnight polysomnography was performed in all children. Apnea–hypopnea index (AHI), baseline and lowest O_2 saturation, baseline and peak end tidal CO_2, and total number of obstructive apneas, hypopneas, central apneas and mixed apneas were measured during each polysomnogram. Children were subdivided into the following age groups: 1–2, 3–5, 6–11 and 12–18 years. Polysomnograms were classified into normal, mild, moderate and severe categories.
Results: Three hundred and sixty-three children were studied; 45 children were ages 1–2 years, 159 children were ages 3–5 years, 137 children were 6–11 years and 22 children were 12–18 years. Although there appears to be a trend towards a greater mean number of obstructive apneas, hypopneas, central apneas, mixed apneas, a higher mean AHI, lower mean SaO_2 nadir, and a higher mean $PETCO_2$ in the younger age groups when compared to the older groups, a Student's *t*-test demonstrates that there is no statistical significance for most OSA parameters. An analysis of variance using the *F*-test reveals statistical significance ($p < 0.01$) when children ages 1–2 were compared to those 3–5, 6–11 or 12–18 years of age for the variables AHI, mean number of central apneas, hypopneas and mixed apneas. When comparing patients in the various severity categories, children ages 1–2 years show a distinct distribution with a larger percentage in the moderate to severe categories. Chi square analysis reveals a significant difference between the frequency distribution of children in age group 1–2 years and that of the other age groups ($p < 0.01$).
Conclusion: There is a predilection for children less than 3 years of age to have more severe obstructive sleep apnea as documented by polysomnography. Central apnea also appears to be more common in this age group. These findings may be explained by anatomic and physiologic differences related to age and support a period of observation following adenotonsillectomy in younger children.

1. Introduction

Adenotonsillectomy (T&A) is a very common surgical procedure performed in children. In recent years, there has been a greater awareness of the potential health risks associated with obstructive sleep apnea (OSA) and this condition has now surpassed recurrent tonsillitis as the most frequent indication for surgery [1]. In most cases, this surgery can be safely performed as an outpatient procedure. However, there are some children who are at higher risk for postoperative complications and should not be considered candidates for outpatient surgery.

Of primary concern postoperatively for these children is respiratory compromise. Children with OSA can experience complications related to post-obstructive pulmonary edema, airway swelling, and poor ventilatory responses after the administration of

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anesthetic agents. Certainly, it would be beneficial to have the ability to identify those children who are most at risk for problems.

Some reviews regarding postoperative complications seem to indicate that age is an important risk factor, with the youngest children being at greatest risk. Although a number of studies are available, they are based on small sample sizes and many did not evaluate the children with polysomnography preoperatively [2–7]. The purpose of this study, therefore, was to investigate age specific OSA abnormalities in children by polysomnography. If differences do exist across various age groups, it may be possible to improve our recognition of children at higher risk and expand our understanding of why select groups of children have greater morbidity.

2. Materials and methods

The polysomnograms of children (1–18 years of age) with OSA diagnosed by overnight polysomnography between January 1998 and January 2001 were reviewed. Children included in the study had evidence of adenotonsillar hypertrophy but no other co-existing medical problems. Children with neuromuscular disorders, craniofacial syndromes, prematurity, cardiopulmonary disease, failure to thrive, hematological disorder, malignancy and obesity were excluded. The study was approved by Childrens Hospital Los Angeles Committee on Clinical Investigations (Institutional Review Board).

Overnight polysomnography was performed in all children. All testing was performed in the Sleep Physiology Laboratory with continued observation of the child by a polysomnography technician skilled in pediatric polysomnography. Polysomnograms 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) end-tidal carbon dioxide pressure ($PETCO_2$), sampled at the nose or mouth by capnography; (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 (SaO_2), by pulse oximetry (model N 200: Nellcor); (6) oximeter pulse wave form; (7) electro-oculogram; (8) electro-encephalogram; (9) chin electromyogram; (10) actimeter (placed on the hand); and (11) sensor placed over neck to monitor snoring.

The following parameters were evaluated: (1) obstructive apnea, defined as complete cessation of air flow at the nose and mouth for two or more respiratory cycles; (2) obstructive hypopnea, defined as a reduction in airflow on thermistor for $\geq$6 s (tracing to <50% of the baseline); (3) number and duration of central apneas >10 s and central apneas of any length associated with bradycardia or desaturation; (4) number of mixed apneas (apneas with both central and obstructive components); (5) obstructive apnea/hypopnea index (number of obstructive apneas, mixed apneas and hypopneas per hour of sleep (AHI)); (6) hypoventilation ($PETCO_2$ >45 mmHg) with the highest $PETCO_2$ scored; (7) oxygen desaturations ($SaO_2 < 95\%$) and SaO_2 nadir; and (8) presence or absence of snoring, paradoxical breathing, chest wall retractions, and gasping. The total length of each study was also recorded.

The mean values of the measurements for each age were computed and the Student's *t*-test was applied to test for significance between ages. Various combinations of *F*-ratios were calculated and compared to determine if a significant disparity in variance existed across age groups.

The data was further distributed such that children were subdivided into the following age groups: 1–2, 3–5, 6–11 and 12–18 years. Polysomnographic findings were classified as normal or abnormal based on criteria previously established [8]. A normal polysomnogram was defined by an AHI <1, SaO_2 nadir >94 or highest $PETCO_2$ <46. Mild OSAS was defined by an AHI of 1–2, SaO_2 nadir of 90–94% or highest $PETCO_2$ of 46–49. Moderate OSAS was defined by and AHI 3–5, SaO_2 nadir of 85–89% or highest $PETCO_2$ of 50–54. Severe OSAS was defined by an AHI >5, SaO_2 nadir <85 and highest $PETCO_2$ >54. Normal studies or those classified as having no evidence of OSAS were identified when all three measurements fell into the normal category. Studies in which at least one of the three parameters was categorized as mild but with no other measurement worse than mild, were defined as mild OSAS. Studies in which at least one of the three measurements was categorized as moderate were defined as moderate OSAS. The moderate OSAS category was further subdivided into moderate OSAS 1 (at least one or more measurements in the moderate range but none in the severe group), moderate OSAS 2 (at least one measurement in the severe range) and moderate OSAS 3 (at least two measurements in the severe range). Finally, severe OSAS was characterized when all three measurements fell into the severe category. Analysis was performed to determine if the frequency distribution of these categories was significantly different between age groups using the chi square method.

3. Results

The overnight polysomnograms of 363 children were reviewed. Forty-five (12.4%) children were ages 1–2 years, 159 (44%) children were ages 3–5 years, 137 (38%) children were 6–11 years and 22 (6%) children were 12–18 years. The age range of children studied was 1.2–18.5 years with a mean of 4.5 years. The average duration of the polysomnograms was 350 min. Although there is a trend towards a greater mean number of obstructive apneas, hypopneas, central apneas, mixed apneas, a higher mean AHI, lower mean SaO_2 nadir, and a higher mean $PETCO_2$ in the younger age groups when compared to the older groups, a Student's *t*-test demonstrates that there is no statistical significance for most OSA parameters (Table 1). There are a few exceptions which include mean AHI, central apnea and mixed apnea, where significant differences ($p < 0.01$) between ages 1–2 are noted when compared to ages 6–11 and 12–18. An analysis of variance using the *F*-test reveals statistical significance ($p < 0.01$) when children ages 1–2 were compared to those 3–5, 6–11 or 12–18 years of age for the variables

Table 1
Comparison of mean values between age groups for OSA parameters.

OSA parameter	Measured *t* ratio		
	$t_{A/B}$	$t_{A/C}$	$t_{A/D}$
AHI	2.32	3.13	2.72
CENT	2.01	3.20	5.31
HYPT	1.94	2.08	1.79
MXDT	1.31	1.69	2.64
OAT	1.40	2.72	2.24
OAL	1.87	1.90	1.25
HYPL	0.28	1.37	0.66
CSAL	−1.70	0.92	1.44
MXDL	−0.75	0.06	0.45
MSAT	−1.00	−1.06	−1.14
LSAT	−3.10	−3.15	−1.73
MPET	1.70	1.92	2.44
HPET	1.14	1.50	0.79
Student's *t*-test at 1% significance level	2.41–2.42	2.41–2.42	2.41–2.42

$t_{x/y} = (\bar{x} - \bar{y})/\sqrt{(S_x^2/n_x) + (S_x^2/n_y)}$. A: age 1–2 ($n = 45$); B: age 3–5 ($n = 159$); C: age 6–11 ($n = 137$); D: age 12–18 ($n = 20$). AHI: apnea/hypopnea index; CENT: central apnea/h; HYPT: hypopnea/h; MXDT: mixed apnea/h; OAT: obstructive apnea/h; OAL: average duration of obstructive apnea; HYPL: average duration of hypopnea; CSAL: average duration of central apnea; MXDL: average duration of mixed apnea; MSAT: mean O_2 saturation; LSAT: O_2 saturation nadir; MPET: mean $PETCO_2$; HPET: peak $PETCO_2$.