Comparison of Polygraphic Parameters in Children With Adenotonsillar Hypertrophy With vs Without Obstructive Sleep Apnea

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Objective: To compare the polygraphic parameters in children with adenotonsillar hypertrophy (ATH) with vs without obstructive sleep apnea (OSA).

Design: Prospective controlled study.

Setting: Hospital-based pediatric otolaryngology practice.

Patients: Children with ATH.

Interventions: The children enrolled in the study underwent polysomnography. According to the apnea index (AI) (a patient who has at least 1 episode of apnea per hour of sleep is considered to have apnea), they were classified as having ATH with OSA or ATH without OSA.

Main Outcome Measures: We evaluated polysomnography parameters to describe the macrostructure of sleep (sleep efficiency, nonrapid eye movement stages 1-4, and rapid eye movement) and the microstructure of sleep (using electroencephalogram results and movement arousals) and respiratory events.

Results: Twenty children were classified as having ATH with OSA and 17 as having ATH without OSA. We found no significant differences in sleep macrostructure and microstructure between the ATH groups with vs without OSA. Apnea-hypopnea indices (AHI), respiratory disturbance events, hypopnea events in rapid eye movement and AHI, AI, respiratory disturbance events, obstructive events, hypopnea events, the duration of obstructive events, and hypopnea events during non-rapid eye movement were more frequent or of longer duration in children with OSA vs those without OSA (P<.05).

Conclusions: Obstructive sleep apnea should be considered a disorder on the continuum of ATH. To our knowledge, our results clearly and for the first time demonstrate that more severe respiratory disturbances seem to be important risk factors for ATH to develop into OSA in children.

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Adenotonsillar hypertrophy (ATH) in patients with recurrent upper respiratory tract infections is associated with obstructive manifestations (eg, mouth breathing, snoring, night cough, and hyponasal voice) and with symptoms of recurrent sinusitis and otitis media. It is the most common cause of upper airway obstruction and obstructive sleep apnea (OSA) in children.

Tonsillectomy and adenoidectomy are the most appropriate therapies for most children with OSA. About 80% of symptoms disappear after treatment; there is normalization of overnight respiratory parameters; and the children’s behavioral, learning, and neurocognitive deficits may be significantly reduced. A small percentage of children are not cured by tonsillectomy and adenoidectomy; however, 98% of children with ATH have no sleep-related breathing disorders. That is to say, the relationship between ATH and OSA is still unclear.

Polysonmography (PSG) is currently the gold standard for the detection and assessment of the severity of OSA in children. The purpose of this study is to compare polygraphic parameters between ATH in patients with vs without OSA.

METHODS

PATIENTS

Thirty-seven children with ATH (28 boys and 9 girls; mean age, 7.5 years [range, 3-15 years])
PSG, an EEG frequency shift greater than 3 seconds, was modified for children to frequency shifts greater than 1 second. Depending on a child’s maturation, there is mostly rhythmic activity (4-7 Hz) or frequencies greater than 16 Hz (mostly EMG artifacts) that correspond to activation; in older children we also see α activity (8-13 Hz). Delta bursts were scored as arousals only when they occurred within an EEG frequency shift. During REM sleep, arousals were scored if the change in EEG was accompanied by an increase in the amplitude of the submental EMG signal. A minimum of 10 continuous seconds of intervening sleep was necessary to score a second arousal. At the same time, parameters were used to characterize leg movement arousals by tibialis anterior EMG. Movement arousals were defined by an EMG activation; in this case, the activation of musculus tibialis anterior together with an activation in any other polygraphic parameter (eg, heart rate or EEG).

The following respiratory parameters were evaluated: obstructive, mixed, and central apneas, and hypopnea longer than 3 seconds in duration were included to calculate the apnea-hypopnea index (AHI) per hour of total sleep time. Furthermore, heart rate and oxygen saturation during the total sleep time were analyzed. Artifacts in heart rate and oxygen saturation recordings were excluded before they were automatically analyzed using Analysis Manager software (version 7.1; Rembrandt).

STATISTICAL ANALYSIS

We performed statistical analysis using SPSS statistical software (version 10.0; SPSS Inc, Chicago, Ill). Nonparametric statistical analysis was used. We performed analysis of changes in score over time using the Wilcoxon signed rank test and comparisons between groups by calculating change scores and using the Mann-Whitney test. We performed comparisons between multiple groups using the Kruskal-Wallis test. P<.05 was considered significant.

RESULTS

Thirty-seven children who were involved in the study had a medical history of ATH. There were 28 boys (76%) and 9 girls (24%). The mean age was 7.5 years (range, 3-15 years).

Of those 37 children, 20 (17 boys [85%] and 3 girls [15%]) had OSA according to PSG criteria. The median age was 6.5 years, the mean (SD) age was 7.38 (2.43) years, and the mean (SD) body mass index (calculated as weight in kilograms divided by height in meters squared) was 17.84 (3.70). Among the 17 children with ATH but without OSA, the median age was 8.0 years, the mean (SD) age was 8.12 (3.79) years, and the mean (SD) body mass index was 17.23 (3.29). There was no difference in distribution of the age ranges between children with ATH with vs without OSA (Figure 1).

There was no difference in sleep efficiency between children with ATH with vs without OSA (Figure 2).

The percentage of sleep stages NREM 1 through 4 and REM did not differ in children with ATH with vs without OSA. Also, there were no differences in EEG arousals (Figure 2).

In children with both ATH and OSA, 93.70% of all obstructive apneas and 92.99% of all hypopnea occurred during NREM sleep.

The AHI, number of respiratory disturbance events, and AI were significantly greater in children with ATH...
The age distribution of children with adenotonsillar hypertrophy (ATH) without obstructive sleep apnea (OSA) vs children with OSA.

Figure 2. Sleep architecture of adenotonsillar hypertrophy (ATH) with obstructive sleep apnea (OSA) compared with ATH without OSA. This figure shows the sleep efficiency (SE, calculated as total sleep time [TST] divided by total sleep period [TST/TSP] × 100%) and the percentage of sleep states for the TSP in children with ATH without OSA vs with OSA. There was no significant difference in the macrostructure and microstructure of sleep between the 2 groups. ARI indicates the arousals index; n/h, number per hour; REM, rapid eye movement; and S, nonrapid eye movement stage. Error bars indicate the range of 1 SD on each parameter.

with vs without OSA (Table). The number of respiratory disturbance events, AHI, AI during NREM and respiratory disturbance events, and AHI during REM were significantly greater in children with ATH with vs without OSA (Table). The AIs during REM were higher in children with ATH with vs without OSA, but there were no significant differences.

During REM sleep, only hypopnea events were significantly more frequent in children with ATH with vs without OSA (Table); however, among obstructive events, central events, and mixed events and their average, longest, and total durations, there were no significant differences between children with ATH with vs without OSA. Among the average, longest, and total hypopnea event durations, there were also no significant differences between the 2 groups.

Hypopnea events, obstructive events, and their total duration in NREM sleep were significantly more frequent and of longer duration in children with ATH with vs without OSA (Table). There were no significant differences between children with ATH with vs without OSA on central events, mixed events, and their average, longest, and total durations.

This study evaluated macrostructure of sleep, microstructure of sleep arousals, and respiratory disturbance events in children with ATH. We found that there were no differences in sleep macrostructure and microstructure between ATH with OSA and ATH without OSA. The AHI, respiratory disturbance events, and hypopnea events in REM and the AHI, AI, respiratory disturbance events, obstructive events, hypopnea events, and the duration of obstructive and hypopnea events in NREM were found to be more frequent or of longer duration in children with ATH with vs without OSA.

Several investigators have found that sleep pattern changes are less marked in children with OSA. Adults with OSA often have decreased slow wave and REM sleep. Infants with OSA have decreased REM time. The reason for these differences between these age groups is unclear. As shown in this study, there was reduction of REM and increase of NREM stage 1 in children with ATH compared with healthy children. A possible explanation is that children with OSA may have subtle changes in sleep architecture that cannot be detected by standard EEG techniques and that may require more sophisticated types of analysis, such as EEG spectral analysis. The proportions of the various sleep stages in our study were unbalanced,

Table. The Differences in Polygraphic Parameters of Children With ATH With OSA vs Without OSA

<table>
<thead>
<tr>
<th>Parameter</th>
<th>ATH Without OSA</th>
<th>ATH With OSA</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total respiratory disturbance events, No.</td>
<td>22.59 (17.14)</td>
<td>104.30 (74.50)</td>
<td>.001</td>
</tr>
<tr>
<td>AHI (TST), No. per hour</td>
<td>4.02 (5.55)</td>
<td>13.42 (9.16)</td>
<td>.001</td>
</tr>
<tr>
<td>AI (TST), No. per hour</td>
<td>0.20 (0.30)</td>
<td>8.87 (14.37)</td>
<td>.01</td>
</tr>
<tr>
<td>Respiratory disturbance events during REM sleep, No.</td>
<td>1.76 (3.05)</td>
<td>6.75 (6.49)</td>
<td>.005</td>
</tr>
<tr>
<td>AHI during REM sleep, No. per hour</td>
<td>3.99 (5.58)</td>
<td>13.48 (9.77)</td>
<td>.001</td>
</tr>
<tr>
<td>AI during NREM sleep, No. per hour</td>
<td>0.20 (0.27)</td>
<td>5.96 (7.00)</td>
<td>.002</td>
</tr>
<tr>
<td>Hypopnea events during REM sleep, No.</td>
<td>1.29 (2.62)</td>
<td>4.25 (4.14)</td>
<td>.01</td>
</tr>
<tr>
<td>Obstructive events during NREM sleep, No.</td>
<td>1.70 (2.26)</td>
<td>38.72 (46.38)</td>
<td>.002</td>
</tr>
<tr>
<td>Duration of obstructive events during NREM sleep, min</td>
<td>1.65 (4.92)</td>
<td>17.34 (15.74)</td>
<td>.001</td>
</tr>
<tr>
<td>Hypopnea events during NREM sleep, No.</td>
<td>19.12 (16.68)</td>
<td>54.70 (45.72)</td>
<td>.003</td>
</tr>
<tr>
<td>Duration of hypopnea events during NREM sleep, min</td>
<td>7.86 (7.43)</td>
<td>22.75 (15.93)</td>
<td>.001</td>
</tr>
</tbody>
</table>

Abbreviations: AHI, apnea-hypopnea index; AI, apnea index; ATH, adenotonsillar hypertrophy; NREM, nonrapid eye movement; OSA, obstructive sleep apnea; REM, rapid eye movement; TST, total sleep time.

*Data are given as mean (SD).
but there was no significant difference of sleep macrostructure between ATH with OSA and ATH without OSA.

Children with OSA have more arousals than healthy children. Arousals in the context of sleep-related breathing disorders are thus beneficial because ventilation is restored, but the adverse consequences of frequent arousals include sleep disturbance and deficits in daytime functioning. Mograss et al described EEG arousals after only 39.3% of respiratory events in quiet sleep and 37.8% of events in active sleep of children. In our study, the arousals index was higher than the AHI, and the different conclusions probably stem from differences in the definition of arousals: one group included subcortical arousals (ie, without EEG changes) and the other was confined to EEG arousal. But there was no significant difference in sleep microstructure between ATH with OSA and ATH without OSA.

In addition, there was no significant difference in sleep macrostructure and sleep microstructure between ATH with OSA and ATH without OSA, suggesting that OSA should be considered a disorder on the continuum of ATH.

In children, airway obstruction is often predominant in REM sleep owing to the loss of upper airway and intercostal muscle tone that is most marked in this sleep state. Despite this, REM sleep continues to be present in normal amounts in children with OSA, although microdisruption of REM sleep may be present. We found that few respiratory events occurred during REM sleep; this is in contrast to a report by Morrelli et al. In our study, 6.30% of all obstructive apneas and 7.01% of all hypopnea occurred during REM sleep. We also found that the AHIs and the numbers of total respiratory disturbance events and hypopnea events were higher in children with ATH with vs without OSA. Our findings demonstrate that a distinct increase in the frequency of hypopnea events was the main difference between children with ATH with vs without OSA during REM sleep.

In the current study, 93.70% of all obstructive apneas and 92.99% of all hypopnea occurred during NREM sleep. This finding is similar to reports in adults, in whom obstruction occurs more commonly during NREM sleep than during REM sleep. As with adults, the apneas were of longer duration during REM sleep than during NREM sleep and were associated with more profound desaturation. In the present study, the durations of obstructive events and hypopnea events in NREM were longer in children with ATH with vs without OSA. The AHI, AI, and frequency of respiratory disturbance events, obstructive events, and hypopnea events were higher in children with ATH with vs without OSA.

We found significant differences of respiratory disturbance events between ATH with OSA and ATH without OSA, especially in NREM sleep. We speculate that hypopnea events, obstructive events, and their total duration in NREM sleep played important roles in OSA owing to ATH.

In summary, this study demonstrated that there were no significant differences in sleep macrostructure and sleep microstructure between ATH with OSA and ATH without OSA, and that OSA should be considered to be a disorder on the continuum of ATH. To our knowledge, these results clearly and for the first time demonstrate that hypopnea events, obstructive events, and their total duration in NREM sleep and hypopnea events in REM may be important pathologic mechanisms of OSA owing to ATH.

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Author Contributions: Drs Zhang and Li had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. Study concept and design: Zhang, Li, and Guo. Acquisition of data: Zhang and Huang. Analysis and interpretation of data: Zhang and Zhou. Drafting of the manuscript: Zhang and Guo. Critical revision of the manuscript for important intellectual content: Zhang, Li, Zhou, and Huang. Statistical analysis: Zhang, Zhou, and Huang. Administrative, technical, and material support: Zhang, Li, and Guo.

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REFERENCES


