ORIGINAL ARTICLE

Clinical and Polysomnographic Correlation in Sleep-related Breathing Disorders in Children☆

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KEYWORDS
Sleep-related breathing disorders in children; Nocturnal polysomnography; Obstructive sleep apnoea syndrome in children; Apnea–hypopnoea index

Abstract
Introduction: Although polysomnography is the gold standard test for sleep-disordered breathing in children, there is controversy about its indication in all cases. Among the arguments both for and against is the lack of correlation between objective values and the symptoms.
Objective: To evaluate the correlation between clinical data and apnea–hypopnoea index (AHI) in our work environment.
Material and methods: We compared the preoperative clinical symptoms and AHI statistically in 170 children with sleep-disordered breathing who underwent polysomnography. We also analysed the correlation to postoperative level, with a subgroup of 80 children who underwent adenotonsillectomy with 1 year of polysomnography follow-up.
Results: Before surgery, only the degree of tonsillar hypertrophy was statistically significant correlated with AHI. At post-operative follow-up, evidence of correlation between AHI and apnoea was observed: 38.1% of children improved in the group with persistence and 66.7% in the disease resolution group (P=.023). In addition, the correlations showed the level of improvement of snoring, as assessed by visual analogue scale. The mean was 5 points lower in the persistent group and 6.1 lower in the disease resolution group (P=.047).
Conclusion: Despite the limitations in the correlation between clinical data and polysomnography, especially in preoperative results, polysomnography remains the gold standard diagnostic tool. Efforts should be made to obtain objective parameters that provide higher levels of correlation.
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Correlación entre la clínica y la polisomnografía en los trastornos respiratorios del sueño infantil

Resumen

Introducción: A pesar de que la polisomnografía supone la prueba diagnóstica por excelencia de los trastornos respiratorios del sueño en niños, existe controversia sobre su indicación en todos los casos. De entre los argumentos utilizados, tanto a favor como en contra, se encuentra la falta de correlación existente entre sus valores objetivos y la sintomatología. Objetivo: Evaluar la correlación entre los datos clínicos y el índice de apnea–hipoapnea (IAH), en nuestro entorno de trabajo.

Material y método: Se comparó estadísticamente la clínica preoperatoria y el IAH de 170 niños con trastorno respiratorio del sueño, sometidos a polisomnografía. También se evaluó la correlación a nivel postoperatorio, con un subgrupo de 80 niños intervenidos de adenoi.migdalcotomía con seguimiento polisomográfico a un año.

Resultados: A nivel preoperatorio únicamente el grado de hipertrofia amigdalar mostró correlación significativa con el IAH. A nivel postoperatorio se evidencia una correlación entre el IAH y las apneas observadas: 38,1% de los niños mejoran según los padres en el grupo con persistencia polisomográfica y el 66,7% en el grupo con resolución de la enfermedad (p = 0,023). También muestra correlación el nivel de mejora del ronquido, valorado mediante escala analógica visual. La media bajó 5 puntos en el grupo persistente y 6,1 en el grupo con resolución de la enfermedad (p = 0,047).

Conclusión: A pesar de las limitaciones en la correlación entre la clínica y la polisomnografía, especialmente en el preoperatorio, la prueba objetiva por excelencia sigue siendo esta. Deben hacerse esfuerzos para conseguir parámetros objetivos que aporten mayor nivel de correlación.

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Introduction

Sleep-disordered breathing (SDB) in children has been the subject of increasing interest, both from the professionals involved in it and from society in general. This interest stems from the negative consequences that can result from failure to treat it or do so belatedly. Therefore, early diagnosis and treatment are strongly recommended.\(^1,^2\)

The diagnostic test of choice for SDB in children is nocturnal polysomnography (PSG).\(^1-^2\) as it is not only useful for diagnosis, but also to assess its severity, plan treatment and carry out its monitoring.\(^1,^3,^4,^5\)

There is currently much controversy about the indication and need to perform a study with PSG in children presenting SDB symptoms. There are extremely divergent positions depending on the literature reviewed. On one hand, neurophysiologists and paediatricians advocate conducting the study in all children before indicating surgery.\(^6-^9\) By contrast, in otolaryngology publications the view is almost the opposite,\(^10-^13\) although with some outstanding qualifications. Between the two extremes we can find the position of pulmonologists, who support the performance of a sleep study before surgery, but who advocate conducting a respiratory polygraph.\(^1,^14\)

All positions provide interesting and sound arguments, but interestingly, one used by all to support their theses is the lack of correlation between the subjective data provided by parents about the symptoms of their child and the objective data obtained by the PSG, especially the apnoea–hypopnoea index (AHI).

In our Otolaryngology Service at a private hospital, we conducted PSG systematically on those children with symptoms compatible with SDB before indicating treatment and 1 year after surgery.\(^15\) The present study aims to analyse the level of correlation between symptoms and epidemiology of children with SDB and objective PSG data, namely the AHI, within our work environment, both before surgery and 1 year after it.

Methods

For the analysis of the correlation between symptoms and PSG data before surgery we considered the population from a prospective database including 170 consecutive children, aged between 2 and 10 years, who attended the otolaryngology consultation with clinical suspicion of SDB. This population was part of the group of patients enrolled in 2 prospective studies on the negative consequences of SDB and the effectiveness of adenotonsillectomy. Both studies were approved by the Clinical Trials Committee of our centre. All parents who accepted taking part in these studies signed an informed consent form.

In order to analyse this correlation 1 year after surgery, we included 80 consecutive cases of the 170 who had previously undergone adenotonsillectomy (AT) and had completed 1 year of follow-up. The data on the 80 cases included physical examination and PSG, before and 1 year after the intervention. The PSG technique has already been described in previous publications.\(^16\)
Children whose parents agreed to their inclusion in the above studies were examined based on a questionnaire given to their parents which included items on infant sleep, breathing problems and behavioural and neurocognitive disorders. These questionnaires were passed at the time of the first consultation and, in case of undergoing surgery, 12 months after it. Parents were guaranteed, in writing, the confidentiality of their responses.\textsuperscript{15}

The issues considered in the questionnaires were regarding 3 general aspects. Those concerning breathing difficulties during sleep: snoring, which was assessed by a visual analogue scale (VAS) ranging between 0 and 10, nasal respiratory distress, presence of observed apnoeas and daytime sleepiness. The second part was connected to the quality of sleep and asked about the presence of nocturnal enuresis, restless sleep, abundant sweating during sleep, bruxism, painful legs, night terrors and sleepwalking. Lastly, the third section referred to behavioural and knowledge alterations. It investigated whether children had problems with aggression, hyperactivity, delayed language acquisition, memory and concentration compared with other children of the same age and environment. It also asked about the level of academic achievement, as evaluated by parents: high, normal or low.\textsuperscript{15} Except for the level of snoring, which was assessed by a VAS, the remaining items had subjective responses, positive or negative, by the parents.

We also conducted a full ENT exploration, including flexible endoscopy of the upper airway in many cases. Assessment of tonsillar hypertrophy was performed based on the Friedman classification, which grades tonsillar obstruction between 1 and 4.\textsuperscript{17}

Patients who met the criteria for surgery by physical examination, questioning and/or PSG were informed about the surgical indication of AT. This indication was based on at least 2 of the following criteria being met: presence of apnoeas observed by parents every night associated to snoring, tonsillar hypertrophy of Friedman grade 3 or 4 and an AHI greater than or equal to 3 in the PSG. Those children who only met either the clinical or the polysomnographic criterion were offered follow-up in consultation. However, when the AHI level was high and there were no evident symptoms we considered the possibility of repeating the PSG and/or obtaining a video recording during sleep. Cases with evident tonsillar hypertrophy who did not meet the other 2 criteria were not candidates for surgery or follow-up at our centre.

The technique used in this group of patients was tonsillectomy through bilateral extracapsular cold dissection under general anaesthesia. In all cases we associated adenoidectomy by nasopharyngeal curettage. We excluded from this study those patients with missing data, those whose parents did not accept their inclusion therein and, in the second population group with patients assessed 1 year after surgery, those cases whose preoperative AHI was lower than 3.

We performed a statistical correlation study between AHI and epidemiological parameters (age, weight, height, body mass index [BMI] and gender), clinical parameters obtained from the questionnaires and the degree of tonsillar obstruction. In the subgroup of children undergoing operations and monitored after 1 year, we assessed the degree of statistical correlation between AHI and improvement of observed apnoeas or lack thereof, snoring intensity evaluated by VAS and presence or absence of nasal obstruction. To do this, we divided them by AHI greater than or equal to 3 and less than 3, into persistent or resolved cases and in each group we assessed the percentage of patients with clinical improvement.

The anthropometric variables, height and weight, were obtained coinciding with the date of the PSG, with the children wearing no clothes or shoes. These values were subsequently introduced into the Seinaptracker programme for auxological calculation. This programme used age, gender, weight and height to calculate the body mass index (BMI), which was then compared with the normal population standards (Andrea Prader Centre, Zaragoza, 2002, normal maturity) to provide the BMI and Z-score percentiles.

**Statistical Analysis**

In both the preoperative and postoperative groups, and at each time of measurement, we first performed the descriptive analyses, with mean and standard deviation for quantitative observations and percentages for qualitative ones. Comparison of quantitative preoperative variables was performed using the Student t test (according to the homoscedasticity indicated by the Levene test) when comparing 2 groups, with the ANOVA test when comparing more than 2 groups, and with the Chi-square test for qualitative response variables.

The relationship between anthropometric variables (quantitative) and the AHI considered as a quantitative variable was performed using the Pearson correlation coefficient.

In order to assess the pre- and postoperative evolution we performed the McNemar test for qualitative outcome variables and the Wilcoxon test for quantitative variables. We conducted the Pearson Chi-square test to compare the presence of certain factors among those individuals with persistent disease and those without it. Lastly, we evaluated whether the evolution of the “level of snoring assessed by VAS” was different between these 2 groups, before and after surgery, using the ANOVA test for repeated measurements. For all the tests we considered as significant a value of $P<.05$.

**Results**

**Description of the Populations**

**Preoperative Group**

The epidemiological and clinical data of the study population of 170 children are presented in Table 1. The mean AHI among the 170 children was of 7.61±6.03 with a range between 0.17 and 39.6.

**Postoperative Group**

The evolution in this subgroup of the main clinical data of the 80 children 1 year after the AT is presented in Table 2. All variables, both the clinical and the AHI, improved in a statistically significant manner after surgery.
Correlations Between Symptoms and Apnoea–Hypopnoea Index

Preoperative Group
From the comparison between the AHI and the different epidemiological, clinical and physical examination parameters, only tonsillar size gradation following the Friedman scale appeared to be statistically significant. That is, a higher degree of tonsillar obstruction meant a higher AHI ($P<.006$) (Fig. 1). For all other variables, the correlation with AHI was not statistically significant. We found no statistically significant correlation with the epidemiological data, age and gender, or anthropometric variables analysed. Neither was a correlation observed with the clinical data obtained from questionnaires answered by parents, nor in issues relating to breathing difficulties during sleep or its quality, nor in matters concerning behavioural or cognitive abnormalities.

Postoperative Group
The statistical analysis of the 80 cases was verified by comparing the cases considered with persistent disease and without it. This difference was established according to the AHI obtained 1 year after surgery. If this was greater than or equal to 3 then the child was considered to suffer obstructive sleep apnoea/hypopnoea syndrome (OSAHS). Out of the 80 cases, 21 presented an AHI greater than or equal to 3 (26.3%), that is, they suffered persistent disease, whilst 59 cases had an AHI below 3 (73.7%) and, therefore, their disease was considered resolved.

We also considered a variable for each case, indicating whether or not each individual improved clinically with surgery. We compared the percentage of individuals who improved between the disease persistence group and the disease resolution group (Table 3). The snoring variable was compared in 2 different ways. Firstly, through the percentage of patients with a mean VAS which was greater than or equal to 5 who improved in each group, and secondly, by the extent of improvement in the VAS for each group. According to the results obtained, the percentage of children whose observed apnoeas improved was higher in the resolved disease group. The snoring improvement level, as observed by VAS, was also higher in the resolved disease group. Both data were statistically significant.

Discussion
SDB represents a highly prevalent condition among children. Its affects approximately 12% of children in its expression as OSAHS (1%–3%) or as cases of snoring without apnoea (10%–12%).18-20 and it also represents one of the most common indications for adenotonsillar surgery.21,22 It is a

Table 1 Population of 170 Children With Symptoms of SDB Before the Surgery.

<table>
<thead>
<tr>
<th>Concept</th>
<th>Preoperative</th>
<th>Postoperative</th>
<th>Value of $P$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age (months and years)</td>
<td>57.98±21.5/4.8±1.79</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender (male/female)</td>
<td>109 (64.1%)/61 (35.9%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percentile BMI $\geq$ 85</td>
<td>44 (25.9%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percentile BMI $\geq$ 95</td>
<td>30 (17.6%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean snoring level (VAS)$^a$</td>
<td>6.95±1.74</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apnoeas observed always</td>
<td>72 (42.4%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apnoeas observed occasionally</td>
<td>76 (44.7%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nasal obstruction</td>
<td>151 (92.6%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Daytime sleepiness</td>
<td>37 (22.7%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hyperactivity</td>
<td>77 (47.2%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lack of attention</td>
<td>71 (43.6%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Friedman tonsillar grade $^b$</td>
<td>2.94±0.72</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean AHI and extremes</td>
<td>7.61±6.03 (0.17–39.6)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

AHI, apnoea–hypopnoea index; BMI, body mass index; VAS, visual analogue scale.

$^a$ VAS: visual analogue scale between 1 and 10.

$^b$ Friedman classification of tonsillar hypertrophy grades between 1 and 4 (24).

Table 2 Evolution of Clinical Data and AHI in 80 Children Monitored 1 Year After Adenotonsillectomy.

<table>
<thead>
<tr>
<th>Concept</th>
<th>Preoperative</th>
<th>Postoperative</th>
<th>Value of $P$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observed apnoeas$^a$</td>
<td>87.5%</td>
<td>32.6%</td>
<td>&lt;.05</td>
</tr>
<tr>
<td>Mean level of snoring (VAS)$^b$</td>
<td>7.06±1.57</td>
<td>1.24±1.84</td>
<td>&lt;.05</td>
</tr>
<tr>
<td>Cases with mean snoring $\geq$ 5</td>
<td>93.75%</td>
<td>8.75</td>
<td>&lt;.05</td>
</tr>
<tr>
<td>Nasal obstruction$^a$</td>
<td>96.3%</td>
<td>20.1%</td>
<td>&lt;.05</td>
</tr>
<tr>
<td>AHI$^b$</td>
<td>8.13±6.06</td>
<td>2.50±2.44</td>
<td>&lt;.05</td>
</tr>
</tbody>
</table>

AHI, apnoea–hypopnoea index; VAS, visual analogue scale.

$^a$ McNemar test.

$^b$ Wilcoxon test (expressed as mean±standard deviation).
Table 3 Evolution of Clinical Data of the 80 Cases Monitored After Surgery Compared According to Persistence or Resolution of the Disease.

<table>
<thead>
<tr>
<th>Concept</th>
<th>Persistence of OSAHS (AHI≥3)</th>
<th>Resolution of OSAHS (AHI&lt;3)</th>
<th>Value of P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apnoeas observed(^a)</td>
<td>8/21 (38.1%)</td>
<td>38/59 (66.7%)</td>
<td>.023(^*)</td>
</tr>
<tr>
<td>Cases with mean snoring≥5(^a)</td>
<td>16/21 (76.2%)</td>
<td>52/59 (88.1%)</td>
<td>NS</td>
</tr>
<tr>
<td>Difference in mean snoring</td>
<td>−5.05±2.42</td>
<td>−6.1±1.91</td>
<td>.047(^*)</td>
</tr>
<tr>
<td>Nasal obstruction(^a)</td>
<td>17/21 (81.0%)</td>
<td>45/59 (76.3%)</td>
<td>NS</td>
</tr>
</tbody>
</table>

AHI, apnoea-hypopnoea index; OSAHS, obstructive sleep apnoea/hypopnoea syndrome.
\(^a\) Percentage of cases which improved from their symptoms.
\(^*\) P less than .05: statistically significant.

veritable public health problem, both due to its prevalence and to its effect on patients.\(^1,2\)

Despite the recommendations of the American Academy of Pediatrics,\(^3,8,9\) there is considerable controversy over whether diagnostic PSG should be performed routinely, before surgery in all children with suggestive symptoms and subsequently for monitoring. For example, the Spanish Consensus Document states: "All this, with the recognition that the gold standard for diagnosis of OSAHS is the PSG, but, at the same time, being aware that it is clearly impracticable to perform a nocturnal PSG on 2%–3% of the paediatric population".\(^1\)

Depending on the literature reviewed, there are clearly divergent positions. Many child otolaryngology specialists do not routinely request this test before surgery and even less for monitoring,\(^12,22\) whilst others do so selectively.\(^11\) However, when we consider paediatrics or neurophysiology publications, they advocate it systematically.\(^6,7,9\) Pulmonology publications adopt an intermediate position, recommending simplified registries, such as respiratory polygraphs.\(^1,14\)

The arguments used by the advocates of not conducting it systematically include the absence of validated criteria for its interpretation.\(^12,13\) The same criteria employed in adults to interpret a PSG cannot be employed in children, as they could lead to false negatives in some cases. In children there is less fragmentation of sleep than in adults, and episodes of complete obstructive apnoea are not as frequent. Adult criteria based on the AHI fail to identify children with OSAHS. Some argue that 1 obstructive apnoea per hour in a child should be considered pathological, whilst others point to an AHI greater than 3.\(^1,10\) It seems that we should rely more on blood gas criteria, especially PCO\(_2\), and on paradoxical respiratory efforts to assess the severity of OSAHS in children.\(^12\) Another commonly used argument is that both snoring without apnoea and OSAHS have similar consequences on children. In other words, commonly used PSG parameters are very poor predictors of SDB comorbidity.\(^1,13,23–26\)

Other, more widespread arguments against the routine implementation of PSG include lack of availability at all centres, workload pressures and endless waiting lists, shortage of technicians and staff with experience in paediatric PSG and consumption of time and resources.\(^1,11,12\) Otolaryngologists continue to rely on clinical histories and examination. This confidence is supported by several lines of reasoning. One of the most important is the experience of good results obtained after adenotonsillar surgery regarding the overall well-being of children and quality of life studies.\(^12\)

A summary of this reasoning would be that of Ray: in the case of otherwise healthy children, with a history consisting of nocturnal snoring, daytime fatigue, daytime symptoms including drowsiness, changes in behaviour and poor cognitive performance and with a physical examination consistent with adenotonsillar hypertrophy, with or without observed apnoeas, it seems reasonable to proceed with AT without a prior PSG.\(^10\)

Despite this, we must agree on the usefulness of the PSG test. Prior to a surgical procedure which is, obviously, not without risk, it is very interesting to have an objective test, both for surgeons and for parents.\(^7\) Cases with more severe OSAHS have a higher risk of perioperative complications, such as respiratory disorders at the time of extubation, and the identification of this group of patients before surgery can prevent subsequent problems.\(^6,21–25\) There is also a higher risk of these complications among patients with a significant presence of central apnoea before surgery, which is impossible to estimate without a prior PSG.\(^7\)

Finally, another argument in favour of obtaining a PSG is that this test is able to discriminate those children with a higher risk of presenting persistent disease after surgery. Children with a higher AHI before the AT procedure are more likely to suffer persistent disease and probably require additional treatment with a nasal continuous positive pressure mask.\(^7,30,31\) Surprisingly, one of the most common criticisms that can be made of PSG is used both by those for and those against testing before surgery. Almost all authors recognise that the clinical history, with or without physical examination, does not correlate with either the presence or severity of SDB.\(^12–36\)

Children with evident symptoms may have a normal PSG and, conversely, children with scarce symptoms can present significant alterations in their PSG.\(^37\) A recent study conducted among 674 children with habitual snoring showed that their AHI, the PSG parameter most commonly used to characterise the severity of SDB, did not display a Gaussian, bell-shaped behaviour.\(^38\)

The present study assessed the possible correlation between different clinical and exploratory data of 170 children with SDB symptoms. None of the epidemiological parameters: age and gender, showed a statistically significant correlation with the AHI. Neither did the clinical values, obtained through questionnaires on sleep quality, respiratory, behavioural and neurocognitive data, show a significant correlation with the AHI.
Out of the physical examination data, only the level of tonsillar hypertrophy, measured using a Friedman scale, showed a statistically significant correlation with the AHI. Upon reviewing the literature, we found studies indicating that tonsillar size is a poor predictor of the severity of SDB and others indicating that tonsillar size correlates well with the intensity of symptoms.

Subsequently, we collected the 80 cases in the group for whom there was follow-up 1 year after surgery and observed a clear improvement of the clinical data after adenotonsillectomy. The 80 cases studied in the present study confirmed these improvement figures in the 3 parameters analysed: observed apnoeas, snoring intensity assessed by VAS and nasal obstruction.

Based on the AHI criterion, this group was divided into resolved cases and cases with persistent disease. If there was a correlation between symptoms and PSG, there should be more symptomatic children in the persistent group and higher rates of improvement in the group of resolved cases. The presence of apnoeas observed by parents was 38.1% among resolved cases and 66.7% among persistent cases (P=.023), showing a statistically significant correlation with the AHI.

Regarding the intensity of snoring evaluated by parents, the difference between the percentage of children with a VAS score over 5 in the group of persistent cases and resolved cases was not statistically significant. However, this changed when we evaluated the difference in improvement between both population groups: −5.05±2.42 in the persistent group and −6.1±1.91 in the resolved group (P=.047).

Our data indicate that, prior to surgery, the only parameter that appeared to correlate with the AHI was the Friedman degree of tonsillar size. The correlation increased when the intensity level of AHI was analysed (used to separate cases with and without persistence in this study). Among non-persistent cases, apnoeas observed by parents and improvement levels of snoring intensity analysed by VAS improved more. A likely explanation is that the subjectivity of parents increased their accuracy once there was a reference (the symptoms of their children before the AT). Their accuracy decreased when this number did not exist (preoperative symptoms).

Leaving aside other considerations, it does not seem logical to support one position or the contrary on the grounds of lack of correlation. For example, when a good correlation between symptoms and physical examination is not observed, the most widely used objective data of the PSG, that is, the AHI, is not worth doing at all. Or else, from the opposite stance, it should always be obtained because the least reliable source is the patient (in this case, the parents).

A more reasonable position would be to use simplified registration methods, useful to reduce the waiting lists and expenses of a costly test. It also seems reasonable to select those cases where the PSG is advised depending on the clinical manifestations or comorbidities or potential risks of the disease in children.

**Conclusion**

The ideal solution would be to improve the correlation levels and to find formulas which provide an objective and safe test before indicating surgery and as a follow-up tool. Neur-ophysiologists, with the support of physicians and surgeons, should strive to find that a reliable and feasible test which would eliminate the problems used by each side to maintain their extreme positions. That objective test would help us to adopt the most appropriate surgical decision, assess the possible negative impact of the disease regarding its complications and assess the long-term effectiveness of the treatment implemented.

**Conflict of Interests**

The authors have no conflict of interests to declare.

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