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Combination of symptoms and oxygen desaturation index in predicting childhood obstructive sleep apnea

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ABSTRACT

Objective: To develop a screening process of obstructive sleep apnea in children based on a combination of symptoms and oxygen desaturation index (ODI).
Materials and Methods: We performed a retrospective study of 141 Chinese patients who were referred to a pediatric sleep laboratory for possible obstructive sleep apnea (OSA). The parents of each patient answered a questionnaire before their child underwent polysomnography (PSG) in the laboratory. An apnea–hypopnea index (AHI) greater than five on nocturnal PSG was defined as OSA. The nocturnal PSG was interpreted by a sleep laboratory physician. The ODI and occurrence ratio of sleep problems such as snoring, observable apnea during sleep, mouth breathing, and restless sleep, among others were compared between the OSA and non-OSA groups using the chi-square test. Items that indicated statistically significant differences were tested with non-parametric Spearman correlation tests to determine the correlation between these items and AHI. ODI and the items that indicated a statistically significant difference between the OSA and non-OSA groups were analyzed using binary logistic regression. The ODI cut-off point was determined through ODI receiver operating characteristic analysis to distinguish between OSA and non-OSA. The sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated to determine the combination of OSA predictors that exhibited the best diagnostic performance.
Results: Among the 141 patients, 78 (55%) were diagnosed with OSA by PSG. The occurrences of observable apnea during sleep, mouth breathing, and restless sleep were significantly different between the OSA and non-OSA groups (20.5% vs. 4.8%, 85.9% vs. 71.4%, 69.2% vs. 52.4%, respectively, with $P < 0.05$). The median of ODI in the OSA group was significantly higher than that in the non-OSA group. The ODI and the occurrences of observable apnea during sleep, mouth breathing, and restless sleep were correlated with AHI and were important diagnostic factors of OSA in children, as determined through binary logistic regression. The presence of observable apnea during sleep had 95% specificity, 84% PPV, and 4.31 positive likelihood ratio (PLR). When score ≥ 3 (i.e., 3 or 4) was used as the cut-off point, specificity, PLR, and PPV were 0.86, 4.22, and 0.84, respectively. When score ≥ 2 was used as the as cut-off point, sensitivity, NLR, and NPV were 0.92, 0.2, and 0.80, respectively.
Conclusions: Observable apnea during sleep was an independent positive predictive factor for OSA in children. A child with observable apnea during sleep should be referred to a special sleep laboratory for PSG diagnosis. When the total score is 3 or 4 based on a combination of symptoms and ODI, OSA can be diagnosed and the child should be referred to a sleep pediatrician for appropriate intervention. When the total score is 0 or 1, the child can be considered normal but should be monitored. When the total score is 2, the result cannot be determined and the child should be referred to a special sleep laboratory for PSG diagnosis. Thus, a screening process is developed based on a combination of symptoms and ODI.

Abbreviations: OSA, obstructive sleep apnea; PSG, polysomnography; AHI, apnea-hypopnea index; ODI, oxygen desaturation index; ROC, receiver operating characteristic; PPV, positive predictive value; NPV, negative predictive value.

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Obstructive sleep apnea (OSA) in children is characterized by recurrent events of partial or complete upper airway obstruction during sleep, which results in disruption of normal ventilation and sleep patterns, neurocognitive deficits, and cardiovascular morbidities. The incidence of OSA in children is estimated to be 2%, and the peak incidence of OSA occurs between 2 and 8 years of age and parallels the prominent growth of a lymphoid tissue around the airway during these years [1,2]. Polysomnography (PSG) was recommended by an expert consensus panel and was designated by the American Academy of Pediatrics as the "gold standard" test for establishing the presence and severity of OSA in children [3]. PSG is typically performed in specialized sleep centers, attended by a trained technologist. The procedure requires skilled scoring and professional interpretation. PSG is considered expensive, time consuming, and technically intense. For children, the procedure requires a special sleep laboratory, but only a few child sleep laboratories are available worldwide. Thus, the diagnosis of OSA in children through PSG would require a long waiting time. Many patients do not require such a comprehensive procedure to diagnose uncomplicated OSA [4]. This study aims to develop a simple screening method for OSA diagnosis in children.

1. Materials and Methods

1.1. Study Design and Subjects

Children aged 21 months to 12.8 years with suspected OSA referred to our sleep clinic from July 2009 to March 2010 were included in this retrospective study. Patients with known histories of chronic pulmonary and neuromuscular diseases or having previous PSGs were excluded. All the children included in this study didn't do any overnight PSG before they came to our sleep lab. The parent of each patient answered a standardized sleep questionnaire, and all patients underwent overnight PSG. Informed consent for PSG was obtained from the parents. We also acquired IRS approval. The number of IRS approval was 2012036.

1.2. Historical Data

We used a standardized sleep questionnaire that consisted of queries regarding the nighttime and daytime symptoms of the child, as well as other symptoms associated with OSA. The questionnaires were administered by a sleep specialist on the night when the PSG was done. An accompanying parent was allowed to sleep in the laboratory with the child. All data collected were verified by the physician on the following day.

1.3. Polysomnography

Standard overnight PSG was performed (Alice 5, Philips, Respironics, USA) with the accompanying parent sleeping in the same room with the child. The following parameters were measured: four-channel electroencephalography (EEG) with bilateral central and occipital leads, electrooculography (EOG) to measure vertical and horizontal eye movements, electromyography with submental electrodes, electrocardiography, airflow measurement through nose and mouth using a thermistor, respiratory effort measured by thoracic and abdominal plethysmography, pulse oximetry, and tracheal sound (snoring) recording using a microphone secured to the neck. PSG was interpreted by a pediatrician who was trained in sleep medicine and was unaware of the clinical findings. The aforementioned parameters provided equivalent assessments of sleep/wakefulness, apnea/hypopnea indices, and movements/arousals [5–7].

Respiratory events were defined according to the American Academy of Sleep Medicine Manual for the Scoring of Sleep and Associated Events (2007) [8]. An obstructive apnea event was defined as such if it satisfied the following criteria: (1) the event lasted for at least two missed breaths (or the duration of two breaths as determined by a baseline breathing pattern), (2) the event was associated with a $>90\%$ drop in the signal amplitude for $\geq 90\%$ of the entire respiratory event compared with the pre-event baseline amplitude, (3) the event was associated with continued or increased inspiratory effort throughout the entire period of decreased airflow, and (4) the duration of apnea was measured from the end of the last normal breath to the beginning of the first breath that achieved the pre-event baseline inspiratory excursion. Central apnea was defined as associated with an absent inspiratory effort throughout the event and if one of the following conditions was met: (1) the event lasted for 20 s or longer, and (2) the event lasted with at least two missed breaths (or the duration of two breaths as determined by a baseline breathing pattern) and was associated with an arousal, an awakening, or a $\geq 3\%$ desaturation. A hypopnea event was defined as such if it satisfied the following criteria: (1) the event was associated with a $\geq 50\%$ decrease in the amplitude of the nasal pressure or alternative signal compared with the pre-event baseline excursion; (2) the event lasted for at least two missed breaths (or the duration of two breaths as determined by a baseline breathing pattern) from the end of the last normal breathing amplitude; (3) the decrease in the nasal pressure signal amplitude lasted for $\geq 90\%$ of the entire respiratory event compared with the signal amplitude preceding the event; and (4) the event was associated with arousal, awakening, or $\geq 3\%$ desaturation. The stages of sleep and arousal were characterized based on the standard criteria with the aid of EEG, EOG, and electromyography.

Desaturation was defined as a fall in the haemoglobin saturation level (SaO_2) to lower than 3% from the baseline level and an oxygen desaturation index was calculated as the average number of desaturation per hour of sleep.

The apnea–hypopnea index (AHI) was calculated as the average number of apneas and hypopneas per hour of sleep. AHI>5 was considered to indicate clinically significant OSA

1.4. Statistical Analysis

A total of 16 items from the sleep questionnaire were analyzed. Through univariate analysis, categorical variables were compared between the OSA and non-OSA groups by performing chi-square (χ^2) tests. Continuous variables were evaluated with one-sample Kolmogorov–Smirnov normal distribution tests. Normal distribution quantitative data were also compared between groups using two-sample t-tests. Non-normal distribution quantitative data were compared between groups using non-parametric Mann–Whitney tests.

ODI and items that indicated statistically significant differences were tested using non-parametric Spearman correlation tests to determine whether these items and AHI were correlated. Oxygen desaturation index (ODI) and items that indicated statistically significant differences between the OSA and non-OSA groups were analyzed through binary logistic regression. The ODI cut-off point was determined through receiver operating characteristic (ROC) analysis to distinguish between OSA and non-OSA. The sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated to determine the combinations of OSA predictors that exhibited the best diagnostic performance.

All statistical analyses were performed using the SPSS version 13.0 statistical software. All statistical tests were two tailed with 0.05 as the threshold level of significance.