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Brief Communication

The role of nocturnal pulse oximetry in the screening for obstructive sleep apnea in obese children and adolescents

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ABSTRACT

Background and Aim: Obesity is a known risk factor for the development of obstructive sleep apnea (OSA) in children. Early screening is essential because of the possible complications associated with OSA. At present, the gold standard for diagnosing OSA is polysomnography, which however has multiple limitations. The aim of this study is to examine the role of nocturnal oximetry as a screening tool for OSA in obese children and adolescents.
Materials and Methods: This retrospective study included obese children who underwent a polysomnography at the Antwerp University Hospital between November 2010 and May 2014. Their oximetries were scored manually, blinded for the polysomnography results, according to Brouilette et al. OSA was defined as an obstructive apnea–hypopnea index (oAHI) ≥ 2 on polysomnography.
Results: This study included 130 obese patients (38% boys, mean age 12 years). Polysomnography results determined 44 patients (34%) with a diagnosis of OSA. Oximetry results classified 16 patients as positive, 43 as negative, and 71 as inconclusive. Further analysis of the positive and negative oximetry results showed a sensitivity and specificity of 58% and 88%, respectively, with a negative and positive predictive value of 81% and 69%, respectively. A second analysis, using the oxygen desaturation index, showed inferior results in comparison to the score attained by Brouillette (sensitivity 57%, specificity 73%).
Conclusions: These results suggest that oximetry alone is insufficient as a screening tool for OSA in obese children. Other screening methods need to be explored in the future.

1. Introduction

Childhood obesity has reached epidemic proportions worldwide, and its prevalence is still increasing. According to the International Obesity Task Force, 10% of children worldwide express excess body fat [1]. Childhood obesity is associated with several complications, including obstructive sleep apnea (OSA).

OSA is the most severe entity in the spectrum of sleep-disordered breathing characterized by intermittent cycles of upper airway collapse associated with hypoxia and arousal during sleep. It is a prevalent disorder in childhood affecting 2–3% of children [2]. However, the prevalence of OSA is found to be much higher in overweight and obese children and is reported to range between 13% and 59% [3]. The difference in prevalence may be related to a different underlying phenotype distinguishing OSA in obese children from that in normal-weight children [4]. The obesity epidemic has increased its prevalence, thus affecting a large number of children. Several complications are associated with OSA in childhood, including cardiovascular, neurological, and metabolic complications [5–7]. Therefore, a timely diagnosis is important for appropriate treatment. Polysomnography (PSG) is the current gold standard for the diagnosis of OSA in children. Although PSG is an indispensable diagnostic tool in sleep medicine, it is associated with several drawbacks. First, it is an expensive investigation that is time consuming, labor intensive, and not universally available. Second, the limited availability of sleep centers may result in long waiting lists. As a result, a timely diagnosis of OSA is not always possible. Therefore,

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alternative screening methods for OSA are warranted. Studies have shown that the assessment of clinical symptoms and signs is not reliable in predicting pediatric OSA [8]. Nocturnal pulse oximetry is found to be a potential screening method for sleep-disordered breathing in adults and children, although with conflicting results [9–12]. In addition, to the best of our knowledge, no studies have looked at a solely overweight and obese pediatric population. It could be expected that OSA in obese children is associated with more frequent oxygen desaturations because of a more restrictive lung function [3,13]. Therefore, oximetry could be a first-line screening tool for OSA in childhood obesity. The aim of this retrospective study was to examine the role of nocturnal pulse oximetry in the diagnosis of OSA in overweight and obese children and adolescents.

2. Methodology

2.1. Study population

This retrospective study included consecutive overweight children between 1 and 18 years of age who underwent a PSG at the Pediatric Sleep Laboratory of the Antwerp University Hospital between November 2010 and May 2014. Children were excluded from the study in case of infection; a chronic medical condition; or genetic, neuromuscular, or craniofacial syndromes.

2.2. Anthropometry

Height, weight, waist circumference, and waist-to-hip ratio (WHR) were measured using standardized techniques by skilled personnel. The fat mass was measured with bioelectrical impedance analysis, using the Deurenberg formula for children [14]. Body mass index (BMI) was calculated as weight in kilograms over height in meters squared and was further analyzed as *z*-scores, using the Flemish growth study as a reference population [15]. Overweight and obesity were defined according to the International Obesity Task Force criteria [16].

2.3. Polysomnography

An overnight PSG was performed on the patients at the Pediatric Sleep Laboratory of the Antwerp University Hospital. The following variables were continuously measured and recorded by a computerized PSG (Brain radiation therapy [RT], OSG, Rumst, Belgium): electroencephalography (C4/A1 and C3/A2); electrooculography; electromyography of anterior tibial and chin muscles; and electrocardiography. Respiratory effort was measured by respiratory inductance plethysmography and oxygen saturation by a finger probe connected to a pulse oximeter (Xpod, Nonin, Minnesota, USA). Airflow was measured by means of a nasal pressure cannula and thermistor, and snoring was detected by means of a microphone at the suprasternal notch. Using an infrared camera, all patients were monitored on audio/videotape. Respiratory events were scored according to the American Academy of Sleep Medicine guidelines [17]. The obstructive apnea–hypopnea index (oAHI) was defined as the average number of obstructive apneas and hypopneas per hour of sleep. Mild obstructive sleep apnea syndrome (OSAS) was diagnosed by the presence of an oAHI between 2 and 5 and moderate-to-severe OSAS was defined by an oAHI ≥ 5 [18].

2.4. Nocturnal pulse oximetry

The nocturnal pulse oximetry of each patient, obtained during PSG, was manually scored by a researcher who was blinded for the PSG results. The oximetry was scored based on the methodology as described by Brouilette et al. [10], where the following criteria are used: a desaturation is classified by a decrease in oxygen saturation of ≥3% compared to baseline; and a cluster of desaturations is defined by ≥5 desaturation over a period of 10–30 min. An oximetry is considered positive when ≥3 clusters of desaturation are present, and at least three saturations < 90% are present. An oximetry is considered negative when no desaturation clusters and no desaturations <90% are present. An oximetry is considered inconclusive when it does not meet the criteria for positive or negative oximetry.

A lower threshold scoring as described by Velaso Suárez et al. [12] was also used (eg, positive when two desaturation clusters and one saturation <90% are present) to compare different scoring methods.

In addition, all desaturations of ≥3% from the baseline oxygen saturation were quantified, and the oxygen desaturation index (ODI) was calculated as the total number of desaturations divided by the total sleep time. A cutoff value for ODI that corresponded with an oAHI ≥ 2 was then determined; based on this value, the population was redistributed in patients with and without OSA. This was completed by calculating the correlation between $oAHI_{PSG}$ and $ODI_{oximetry}$, and then determining the curve that best fitted this relationship. Using the equation associated with this curve, the ODI value corresponding with an oAHI of 2 could be determined. According to the literature [19], the oximetry was also rescored with the cutoff value for ODI > 2.

2.5. Statistical analysis

All statistical analysis was performed using SPSS 20.0 (SPSS, Chicago, IL, USA). Normality was tested by the Kolmogorov–Smirnov test. Normally, distributed data are presented as mean ± standard deviation. Skewed data are reported as median (range). Specificity, sensitivity, positive predictive value (PPV), and negative predictive value (NPV) of the pulse oximetry versus PSG were calculated. Correlations were calculated using the Pearson's or Spearman's correlation analysis as appropriate. Statistical significance was accepted at $p = 0.05$.

3. Results

This study included 130 overweight and obese patients with an average BMI of 30.3 kg/m^2 (range: 19.7–47.3 kg/m^2), which corresponded to a mean *z*-score of 2.5 (range: 1.5–4.1). The mean age was 12 years (range: 6–17 years), and 38% were male patients. According to PSG, 44 patients (34%) were diagnosed with OSA; 23 (18%) had mild OSA and 21 moderate-to-severe OSA (16%). Table 1 shows the patient characteristics.

ODI measured by oximetry moderately correlated with oAHI measured by PSG ($r = 0.41$; $p < 0.001$). When examining patients with an oAHI < 10, the correlation coefficient slightly decreased ($r = 0.34$; $p < 0.001$). However, no correlation between $ODI_{oximetry}$ and oAHI could be observed in patients with an oAHI >10.

Based on the criteria by Brouillette et al., oximetry classified 16 patients as positive, 43 as negative, and 71 as inconclusive [10]. Further analysis of the positive and negative oximetry results showed a sensitivity of 58% and a specificity of 88%. The NPV and PPV were 81% and 69%, respectively.

A sensitivity of 69% and a specificity of 66% were observed while using a lower threshold scoring as described by Velasco Suárez et al. [12] NPV and PPV were 81% and 50%, respectively.

A cutoff value for ODI that corresponded with an oAHI ≥2 (cutoff value: ODI > 4.31) was determined on a subset of patients (38 patients); based on this value, the population was redistributed in patients with and without OSA. Rescoring based on the ODI of the nocturnal pulse oximetry diagnosed 48 patients with OSA (37%). The sensitivity and specificity were 57% and 73%, respectively. The NPV was 77%, and the PPV was 52%. When a cutoff value for ODI >2 was