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ORIGINAL ARTICLE

Comparing Oxygen Saturation of Normal Children with that of Children with Adenotonsillar Hypertrophy

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Abstract To compare the nocturnal oxygen saturation profiles of children with adenotonsillar enlargement with that of normal children. A 1 year comparative study. The study was carried out at the Otorhinolaryngology Ward of the University College Hospital Ibadan. These comprise of 60 children (1–9 years) with clinically confirmed adenotonsillar enlargement admitted for adenotonsillectomy and 60 normal children matched for age and sex. The biodata and common clinical presentations of the study group were acquired with a structured proforma. The severity of nasopharyngeal obstruction was determined by the adenoidal–nasopharyngeal ratio while the degree of tonsillar enlargement was graded by the Brodsky's classification. The nocturnal oxygen saturation of all the participants were recorded with a wrist worn pulse oximeter. Recording was for at least for 4 h. Oxygen saturation <92 % was regarded as desaturation. The oximetric values of the study and control group were compared. The mean nocturnal SPO_2 (peripheral saturation of oxygen) profiles of children with adenotonsillar enlargement were as follows: basal = 96.86 %, minimum = 84.99 %; maximum = 99 % and average SPO_2 <92 % = 87.74 % while the saturation profiles of the control group were as follows; basal = 97.88 %, minimum = 89.71 %; maximum = 99 %, average SPO_2 <92 % = 90.82 %. Normal children have better nocturnal saturation profiles than children with adenotonsillar enlargement.

Keywords Adenotonsillar enlargement · SPO_2 · Oxygen desaturation index · Pulse oximetry

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Introduction

The adenoids and palatine tonsils are lymphoid structures located in the nasopharynx and oropharynx respectively and are part of the Waldeyer's ring. They form part of the body's mucosa-associated-lymphoid-tissue and are found at the entrance of the upper aerodigestive tract. As such, they constitute part of the body's first line of defense for protection of the lower airways and gastrointestinal tract as well as the development of antigenic memory by the host [1].

The patency of the upper airway depends on the actions of its dilator muscles. When awake, the voluntary mechanism operates to keep these muscles under tonic contraction thus keeping the oropharynx open. But during sleep, especially REM sleep, skeletal muscles, which are under voluntary control, are mostly hypotonic, thus narrowing the oropharyngeal inlet [2].

Most infections/inflammations of the palatine and nasopharyngeal tonsils in children are usually due to viruses and bacteria [3]. Allergy causes antigenic stimulation of these lymphoid follicles which contribute to their enlargement [4, 5].

Repeated viral and bacterial infections of the adenoid and tonsils occur in children who have not yet developed immunity against many viruses like rhinoviruses, adenoviruses and the respiratory syncytial viruses [3]. These viruses are known to cause repeated viral upper respiratory tract infection in children. These repeated infections/inflammations may result in enlargement of these lymphoid follicles. Even when the infections resolve, residual enlargement of the lymphoid tissues may persist leading to narrowing of the nasopharyngeal and oropharyngeal tract. The combined effect of muscular hypotonia that occurs during sleep and adenotonsillar enlargement occasioned by infections and antigenic stimulation may operate in synergy to narrow the airway leading to decreased pulmonary oxygenation or obstructive sleep apnoea.

The size of the adenoid and tonsils varies in children but in general, they attain their maximum size between ages 3 and 6 years and thereafter begin to atrophy [6]. This age bracket corresponds to the period when infections of the adenoids and tonsils occur frequently [3]. Thus the highest frequency of OSA in children occurs within the ages of 2–6 years [7].

The gold standard method for diagnosing OSA is an overnight sleep study or polysomnography (PSG) [8]. However, PSG facilities are not available in many parts of the world. Even in some countries where PSG is available, access is limited. For example, the average waiting time for PSG in the USA is about 3–6 weeks and in Australia this can be as long as 3–6 months [9]. This long waiting time delays diagnosis and treatment and thus increases the anxiety of care givers. A simpler but yet effective testing modality to overcome these problems is pulse oximetry which is a tool that can determine oxygen saturation [10, 11] with the added benefit of cost reduction and reduced waiting time. The device is easy to use and recording is accomplished over a shorter period of time. But the oximeter could measure the movement of the patient as oximetric data, showing a false oxygen desaturation as the result. This error could be detected by comparing the oximetric data with the pulse rate. In this setting, there will be no corresponding bradycardia or decrease in pulse rate if the oximeter had recorded patient's movement as desaturation. [11].

In sleep studies, oxygen desaturation has been defined as decrease $\geq$4 % from baseline [12, 13], or any value less than 92 % [14].

Patients and Method

Study Design

It was a 1 year comparative study. An ethical clearance for the conduct of the study was obtained from the University of Ibadan, Nigeria/University College Hospital (UCH) Ibadan, Nigeria ethical review board. Informed consent was obtained from all the parents of the participants.

Study Setting

It was a hospital based study which was undertaken at the Department of Otorhinolaryngology of the UCH, Ibadan, Nigeria.

Sampling Criteria/Technique

Sixty children aged 1–9 years with adenotonsillar enlargement admitted for adenotonsillectomy at the UCH, Ibadan who met the inclusion criteria were selected for this study.

The control population were made up of 60 children matched for age and sex with no features of adenotonsillar enlargement. The control population was drawn from children of members of the UCH, Ibadan.

Study Period

July 2011–2012.

Inclusion Criteria

All children ($\geq$1–9 years) with clinically confirmed adenotonsillar enlargement and whose parents gave written consent to participate in the study.

Exclusion Criteria

Study Group

- Infants.
- Children scheduled to undergo only adenoidectomy or tonsillectomy.
- Children with neurologic, genetic and craniofacial abnormalities.
- Children with co-morbid illness like childhood asthma, seizure disorder, congenital cardiac disease, nasal polyposis or chest infection.

Control Population

- Grade 11 tonsillar enlargement and above
- History of snoring, mouth breathing and recurrent nasal discharge

Data Collection/Procedure

The participants were enrolled as they presented at the ENT clinic of the UCH Ibadan and are admitted to ward. After the preliminary assessment with regards to the inclusion and exclusion criteria, a thorough history was taken and physical examination was done.

The demographic data and common presenting symptoms of the children with adenotonsillar enlargement selected to participate in the study were acquired with a structured proforma.

Oropharyngeal examination was performed and tonsillar enlargement was graded using the Brodsky criteria [15].

A plain radiograph of the post nasal space was done for each participant. The severity of nasopharyngeal occlusion was assessed by the adenoidal–nasopharyngeal ratio [6].

All the participants in the control group had also had oropharyngeal examination. Any child with grade 11 tonsillar enlargement and above was not recruited into the control group.

Most parents and care givers were unwilling to give consent to subject their wards to X-ray for the purpose of this study. So we relied on history alone to rule out adenoid hypertrophy. History of snoring, mouth breathing and recurrent nasal discharge also served as exclusion criteria for the control population.

Sixty children who met the inclusion criteria had nocturnal pulse oximetry done using a wrist worn pulse oximeter, CMS50, with a pediatric probe. CMS50F is manufactured by crucial medical systems in the USA.

Recording lasted for at least 4 h.

Desaturation was defined as SPO_2 <92 % [14].

The oxygen desaturation index (ODI) was calculated. This was the total number of desaturations divided by the number of hours of the test, which for this study was for 4 h.

Oximetry for the control population was undertaken as home study.

Data Analysis

Results were collated and analyzed using the statistical package for social sciences version 21. Demographic and clinical variables were tabulated. Data were summarized by means and standard deviation. The student *t* test was used to compare the oximetry values of the study and control group. The statistical significance was set at $p < 0.05$, two tailed level at 95 % confidence interval.

Results

Demographics

One hundred and twenty children participated in the study. There were 60 children aged 1–9 years in the study group with a mean age of 4.5 years. Twenty-nine of the participants in the study group were males (48.3 %) while 31 were females (51.7 %), giving a male: female ratio of 1:1.1.

Clinical Features Statistics

Presenting Symptoms

Common presenting complaints were snoring (100 %) mouth breathing (100 %), apnoeic attacks (55 %) and restlessness (81.70 %). See Table 1.

The duration of symptoms prior to presentation ranged from 6 to 36 months with a mean duration of 14.25 months.

Adenoidal–Nasopharyngeal Ratio (ANR)

The ANR ranged from 0.58 to 0.92 with a mean of 0.75 ± 0.08.

Five participants (8.3 %) had mild nasopharyngeal obstruction, 34 (56.7 %) had moderate nasopharyngeal obstruction while 21 (35 %) had severe obstruction. See Table 2.

Tonsillar Grade

Grade III and IV tonsillomegaly 30 (50 %) and 25 (41.7 %) respectively were the most common, See Table 3.

Oximetry Variables

The oximetric values for the children with adenotonsillar enlargement are shown in Table 4 while Table 5 shows the saturation profiles of the control group.

A comparison of the saturation profiles of the study and control group (Table 6) shows that children without features of adenotonsillar enlargement had better saturation profiles than those with the adenotonsillar enlargement.

Discussion

Adenotonsillar enlargement is a common childhood problem which may cause obstructive sleep apnoea. However, it has been observed that not all obstructive episode is associated with oxygen desaturation. Drawing from this, it means that not every child with adenotonsillar enlargement who snores, mouth breathes and has apnoeic episodes during sleep has oxygen desaturation.

Adenotonsillectomy has been demonstrated by several studies to be the treatment of choice for obstructive adenotonsillar enlargement [16–18]. Pulse oximetry has been validated to be a reliable modality for monitoring oxygen saturation in children. [10, 11] There is a strong parental satisfaction after adenotonsillectomy owing to the resolution of symptoms of their children/wards. [19] This further

Table 1 Distribution of common presenting symptoms ($n = 60$)

Symptoms	Frequency	Percentage (%)
Daytime hypersomnolence	6	10
Apnoeic attacks	33	55
Recurrent nasal discharges	47	78.3
Nocturnal restlessness	49	81.7
Mouth breathing	60	100
Snoring	60	100

Table 2 Distribution of severity of nasopharyngeal obstruction

Severity of obstruction	Frequency	Percentage (%)
Mild	5	8.3
Moderate	34	56.7
Severe	21	35

Table 3 Distribution of tonsillar enlargement by Brodsky grade

Grade	Frequency	Percentage (%)
Grade II	5	8.3
Grade III	30	50
Grade IV	25	41.7
Total	60	100

Table 4 Oximetric values of study group

Variables	Basal SPO_2 (%)	Min SPO_2 (%)	Max SPO_2 (%)	Average SPO_2 <92 %	ODI
Values	96.86 ± 3.75	84.99 ± 7.96	99.00	87.74 ± 2.59	3.00 ± 3.25

Table 5 Oximetry values of control group

Variables	Basal SPO_2 (%)	Min SPO_2 (%)	Max SPO_2 (%)	Average SPO_2 <92 %	ODI
Values	97.88 ± 0.58	89.71 ± 2.63	99.00	90.82 ± 0.38	0.54 ± 0.32

gives credence to the fact that adenotonsillectomy is the treatment of choice for adenotonsillar enlargement.

Sixty children admitted for adenotonsillectomy were evaluated. Eighty-six percent of the participants were between the ages of 2–6 years which coincided with the period of most frequent infections of the upper respiratory tract and the period of maximum enlargement of nasopharyngeal and palatine tonsil. This finding is similar to reports from other studies. [3, 7, 20].

Table 6 Comparison of oximetry profiles: study versus control

Oximetry variables (%)	Study group	Control group	Sig (two tailed)
Basal SPO_2	96.86 ± 3.75	97.88 ± 0.58	0.04
Minimum SPO_2	84.99 ± 7.96	89.71 ± 2.63	0.00
Maximum SPO_2	99.00	99.00	
Average SPO_2 <92 %	87.74 ± 2.59	90.82 ± 0.38	0.00
ODI	3.00 ± 3.25	0.54 ± 0.32	0.00

The commonest presenting symptoms in this study (Table 1) were similar to that reported in other studies. [16, 17, 20] However, unlike in adults where daytime hypersomnolence is a frequent symptom of obstructive sleep apnoea, [21, 22] it was not so in this study as only 10 % of the participants presented with daytime hypersomnolence. This finding agrees with the observations of Messner et al. [23] and Arrate et al. [16].

The adenoids and palatine tonsils lie in the nasopharyngeal and oropharyngeal airway so it is easily conceivable why their progressive enlargement will increase the severity of obstruction.

Apart from the lateral enlargement of the tonsil which has been used to grade the severity of its enlargement [15], it may also have a significant upward enlargement rather than a lateral one [18] such that an overlap with the nasopharyngeal tonsils occurs at the retropalatal region [24].

The basal SPO_2 found in this study was comparable to that observed by Arrarte et al. [16] in a group of Brazilian children with adenotonsillar enlargement admitted for adenotonsillectomy ($p < 0.53$) but was significantly higher than the values in a subsection of Iranian children admitted for adenotonsillectomy ($p < 0.00$) as was reported by Kargoshaie et al. [17].

The minimum SPO_2 in this study (84.99 ± 7.96) was comparable with the findings of Arrarte et al. [16] ($p > 0.62$) but was significantly lower than that found by Ramos et al. [25] in a group of Portuguese children; 89.1 ± 3.6 % ($p < 0$ 0.00).

All the participants attained an SPO_2 of 99 % as was reported in other studies [16, 17].

The control group had better oximetry profiles than the study group thus suggesting that adenotonsillar enlargement may be implicated in decreased nocturnal oxygen saturation [17].

A search of the literature did not reveal any study that evaluated the average SPO_2 less than 92 % nor was any similar study on this topic in Nigerian children found. Thus this work may serve as a reference document for nocturnal oximetric profiles for children in south west Nigeria with adenotonsillar enlargement and also provide a reference template for normal nocturnal oximetric profiles for Nigerian children.

Some technical challenges that arose were managed as were done in previous studies.

Movement of the hand during recording is usually recorded as desaturation by a pulse oximeter.

To avoid this common error, the oximetric data were compared with the pulse rate as was done in other studies [16, 17].

To ensure better fixation of the oximeter probe the hands of the participants were immobilized with a splint using plaster as was done by Kargoshaie et al. [17].

Conclusion

From this study, children with obstructive adenotonsillar enlargement had lower nocturnal oximetric profiles than children with no features of obstructive adenotonsillar.

Key Message

Obstructive adenotonsillar enlargement may decrease nocturnal oxygen saturation. Thus, in order to prevent long term complications, treatment of this disease should be considered early.

Conflict of interest There is no conflict of interest.

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