Childhood Sleep Disordered Breathing: Epidemiology, Health Implications and Surgical Management in Jos, Nigeria.

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Abstract

Background; Sleep disordered breathing, a concept in Sleep Medicine, has been reported among causes of sudden death from consequences of obstructive sleep apnea on the cardiopulmonary system and brain, frequently under recognized. This study aimed to evaluate its epidemiology, health implications and treatment outcome in our setting.

Method: A cross-sectional study of **c**onsenting childhood sleep disordered breathing participants over a two-year period; August 2017-July 2019, at the Jos University Teaching Hospital in Nigeria.

Re**sults**; We analyzed 83 participants with sleep disordered breathing, accounting for 2.8% of the 2,994 childhood ear, nose and throat consultations, with a male: female ratio of 1.9:1. Their ages ranged from 9 months to 18 years. Eighty three (100.0%) participants had snoring, 23(27.7%) noisy breathing, 10(12.1%) obstructive sleep apnoea and 7(8.4%) obstructive sleep apnoea syndrome. The major risk factor for sleep disordered breathing was obstructive adeno-tonsillar hypertrophy; 75(90.4%). Cardiopulmonary complications; 23(27.7%) were the most frequent among participants. Therapy was surgical with primary post tonsillectomy hemorrhage in 2.4% of participants with a median blood loss of 30.0mls and interquartile range of 25.0ml. There was a positive correlation between the Brodsky's tonsil grade and volume of surgical specimen ($r = 0.388$, $p = 0.0001$). Complete resolution of symptoms was recorded in 79(95.2%) cases.

Conclusion. Childhood sleep disordered breathing is not uncommon with snoring as the most frequent feature. Obstructive sleep apnoea syndrome which correlates snoring severity accounted for half of obstructive sleep

apnoea patients. Cardiopulmonary complications are common, making comprehensive pre-operative evaluation necessary to avoid surgical adverse events.

Key Words-Childhood, Sleep Disordered Breathing, Therapy, Outcome

Introduction

Sleep Disordered Breathing (SDB) is a spectrum of disorders that involves many fields of medicine and ranges from snoring to Upper Airway Resistance Syndrome (UARS) and Obstructive Sleep Apnea Hypopnea Syndrome (OSAHS). Obstructive Sleep Apnoea (OSA) patients have been found to be at risk of sudden death between midnight and 6a.m as opposed to 6 a.m and noon in the general population.[1,2] **T**he severest form, OSAHS, has been identified as a risk factor for diabetes mellitus, cardiovascular diseases, neurocognitive deficits and increased automobile crashes. The Sleep Heart Health Study provided evidence that sleep-related intermittent hypoxemia associated with OSA responsible for hypertension, Coronary Arterial Diseases, heart failure and stroke.[3-6] Wisconsin Sleep Cohort study further demonstrated that even a slightly elevated Apnea Hypopnea Index (AHI) was associated with almost 50% increase in the odds of hypertension in patients with SDB. Further evidence to suggests that stroke patients with OSA are at an increased risk of death.[7,8] Based on prevalence of undiagnosed OSA in the general population, it was estimated that the annual cost of management of its consequences including indirect costs was $18.4 billion.[7,9,10]

Enlarged adenoidal tissue, a cause of nasal obstruction and mouth breathing which may result in dental malocclusions termed "adenoid facies", was first described by Tomes in 1872.[11] Features such as restless sleep, frequent postural changes, excessive sweating, night terror, sleepwalking and enuresis may suggest SDB in children. While excessive daytime sleepiness becomes apparent in children ≥ 6years, Attention Deficit Hyperactivity Disorder (ADHD) is usually predominant in younger children. Unrecognized Obstructive Sleep Apnoea Syndrome (OSAS) in children may result in poor academic performance, failure to thrive and delayed developmental milestones. Early diagnosis of childhood SDB with appropriate interventions are therefore critical in preventing these complications.[12-14]

Observations of periodic breathing in sleep were first reported in the 1850s. At the latter half of the 19th century, several obese persons with extreme daytime sleepiness were labeled the "Pickwickian syndrome."[15] However, Sleep apnea in infants was first described in 1975 in relation to sudden infant death syndrome by Guilleminault in 1976 and other researchers reported OSA as a clinically relevant entity in children.[15-17] We therefore embarked on this study to evaluate the epidemiology, health implications of childhood SDB and the surgical management in our setting.

Methodology

Setting: The study was conducted at the Jos University Teaching Hospital, Plateau State, Nigeria- a public tertiary hospital in Jos, north central Nigeria. The hospital has 620 Beds with over 15 clinical departments which offer preventative, curative, diagnostic and rehabilitative care and has four bordering states as immediate source of referrals.

Study population: All children presenting at the Ear, Nose and Throat clinic who consented to participate in the study were enrolled over a two-year period.

Inclusion criteria; All children who met the criteria in accordance with the Clinical Practice Guideline compendium of American Academy of Oto-laryngology, Head & Neck Surgery(AAO-HNS),1995[18]

Exclusion criteria; Cases with bleeding/coagulation defects, gross cranio-facial anomalies and participants who declined consent were excluded.

Study design: This was a cross sectional study conducted over a two-year period.

Sample size estimation: The minimum sample size (n) for the study was determined using the Leslie Kish formula.[19] Thus, $n=z^2pq/d^2$ at 95%;

Where z = standard normal deviate at 95% Confidence Interval (CI) = 1.96, p = proportion or prevalence (2%) of SDB in a previous study[17], q = complementary proportion (1.0-p), d=precision or tolerable margin of error (5%)]: n=31.

Sample selection method: All participants who met the inclusion criteria, consented to participate in the study and were diagnosed to have SDB were consecutively enrolled in the study.

Procedure; Diagnosis was established from clinical symptoms/risk factors and clinical grading of tonsil enlargement by Brodsky[20] This was complemented by Adenoidal size grading by Fujioka et al[21] from lateral X-ray cephalometry/Adenoid Nasopharyngeal Ratio (ANR) further re-enforced by mirror examination intra-operatively classified in accordance with P. Cassano et al.[22] All clinical diagnoses were confirmed by histopathologic reports.

Data collection; Data were collected over a two year period between 1st August 2017 and 31st July 2019 using a data proforma. These included: biodata, diagnosis, indication for adenoidectomy± tonsillectomy, investigations, treatment and outcome of treatment. Relevant investigations carried out were; Clotting profile (International Normalized Ratio(INR), electro-cardiogram (ECG), lateral X-Ray cephalometry, and anthropometric measurements (weight, height, Body Mass Index, Mid-Arm circumference). The American Society of Anesthesiology (ASA) criteria[23] was utilized to assess patients' fitness for surgery, where ASA I or II were considered fit. The operations were performed under General Anesthesia (GA) using Propofol/Halothane. Patients were administered peri-operative antibiotics and Sodium Etamsylate which causes vasoconstriction at the capillary bed and platelet aggregation. We utilized gauze soaked in 1-2% Xylocaine of 1:1000 adrenaline prepared in 1:200,000 dilution for topical surgical hemostasis. The surgical technique was the Cold Steel Dissection Tonsillectomy and Adenoidectomy (T&A) by the Beckmann curette. Use of diathermy for coagulation of bleeders was employed while duration of procedure was defined as first incision to completion of hemostasis. Estimated blood loss (EBL) was obtained by counting used pieces of blood-soaked gauze (One square inch soaked gauze=10mls of blood) [11] while the blood loss in receiving bottle on completion of surgery was the final volume in the bottle less irrigation fluid already predetermined (150ml).The volume of adenoid/ tonsil surgical specimen was estimated using Archimedes Principle (1 ml = 1g).[24] The surgeons were consultants and specialist registrars. Finally, duration of surgery, hospital stay, complications and final

outcome were documented.

Statistical Analysis: Statistical Product and Service Solution **(SPSS)** version 21.0 Chicago, IL, USA was used for data analysis. The data were extracted from the proforma, coded, entered into a spread sheet and variables subjected to statistical analysis. Association between tonsil grade and volume of tonsil surgical specimens was determined using the Pearson Correlation coefficient(r) at 99% CI with a p-value ≤ 0.01 considered statistically significant. The 95% CI was used with a p-value ≤ 0.05 as statistically significant for the correlation between grade/volume of adenoid/tonsil with surgical blood loss. Findings were displayed in tables, figures.

Ethical Approval: Ethical approval for the study was obtained from the Jos University Teaching Hospital Institutional Health Research Ethical Committee ((JUTH/DCS/ADM/127/XIX/6610). The parents of all children who participated in the study gave consent for the study after a detailed explanation of the nature and risks involved in the study. All information obtained from them was kept confidential and all participants were free to opt out of the study at any time.

Results

Patient characteristics

Out of the 2,994 Childhood ENT consultations over the study period, 83 had Sleep Disordered Breathing, giving a prevalence of 2.8%. These included 54(65.1%) males and 29(34.9%) females giving a male to female ratio of 1.9:1. The condition was commonly seen in the second birth order followed by the first birth order in ratio 5.4:3.9:1. Their ages ranged from 9months to 18years with two peaks at 0-3years; 51(61.5%) and 3years-6years; 19(22.9%) with a median of 3.0years. (Figure 1)

Childhood SDB clinical spectrum and Clinical features

The **s**pectrum commenced with snoring; 83(100.0%), noisy breathing; 23(27.7%), OSA; 10(12.1%) and terminated with OSAS; 7(8.4%). Clinical features were: snoring;83(100.0%), nasal obstruction; 71(85.5%), rhinorrhea; 32(38.6%), fever; 29(35.0%), noisy breathing; 23(27.7%), cardiopulmonary complications; 23(27.7%), dysphagia; 18(21.7), mouth breathing; 18(21.7), odynophagia; 16(19.3%), nasal allergy; 14(16.9%), OSA; 10(12.1%), OSAS-; (8.4%, representing 41.2% of OSA cases), halitosis; 5(6.0%), failure to thrive; 5(6.0%), adenoid facies; 3(3.6%), poor academic performance; 3(3.6%) and previous quinsy; 2(2.4%).

Risk factors for Childhood Sleep Disordered Breathing

Mainly **a**denotonsillar hypertrophy; 75(90.4). Others include ENT allergy; 14(16.9%), adenoid hypertrophy; 4(4.8%), tonsil hypertrophy; 4(4.8%) and cerebral palsy; 3(3.6%).

Summary of Brodsky's grading of tonsil & ANR grading for adenoids

There were 39(47.0%) with Brodsky grade III, 26(31.3%) grade IV and 16(19.3%) were grade II. The remaining 2(2.4%) were grade I while 71(85.5%) had adenoid-nasopharyngeal space ratio of ≥ 0.5 which are grades III & IV and the remaining 12(14.5%) were grades I & II (Table 1)

Summary of investigations results

Their ECG findings were abnormal in 23(27.7%), which were due to myocardial infarction, cor-pulmonale, heart block and cardiac arrhythmias. On coagulation studies, we utilized the INR where the range was 0.52-2.68, mean=1.23 ± 0.26 while 28(29.2%) had abnormal INR >1.3. (Table 2)

Surgical options
The therapy was adeno-tonsillectomy in 75(90.4%), adenoidectomy in 4(4.8%) and tonsillectomy in 4(4.8%) patients.

Estimation of volume of surgical specimens
The volume of surgical specimens of adenoids ranged from 0.20ml to 4.50ml with a mean of 1.56ml ±0.83ml. The right tonsil volume ranged from 1.00ml to 6.00ml with a mean of 2.67ml ±0.99ml while the volume of the left tonsil ranged from 0.80ml to 4.00ml with a mean of.58ml ±0.98ml. The right tonsil was frequently larger than the left (Table 2).

Blood loss assessment
Blood loss ranged from 10ml to 250ml with a median of 30ml and interquartile range of 25ml. From the 81(97.6%) patients who had blood losses of ≤100ml, an estimated 65(78.3%) were ≤50ml. The incidence of primary post tonsillectomy haemorrhage(PTH) was 2(2.4%). The two participants had blood losses of 200ml and 250ml (Table 2)

Surgery duration
The range was 20minutes to 110minutes with a median of 48mins. Sixty six (79.5%) had the procedure in ≤60mins. Of the 5(6.0%) who had blood loss between 100ml-250ml, 4(4.8%) had their surgeries in 60mins-90mins and all were grade IV.

Association between Brodsky's tonsil grade and volume of surgical specimens
The clinical grade equated with the volume of surgical specimen at a certain level of accuracy; mean grade=3. 05 while mean volume=2.67. (Fig. 2) The Pearson's coefficient of correlation between Brodsky's tonsil grade and volume of tonsil surgical specimens at 99% CI, $r = 0.388$, $p = 0.001$.

Correlation between blood loss and Brodsky's tonsil grade
Volume of blood loss positively correlated the size of tonsil. (Figure 3) while the coefficient of correlation 'r' at 95% CI for the correlation between adenoid/tonsil grade or volume with volume of blood loss $r = 0.217$, $p = 0.048$.

Outcome
On hospital stay, 77(92.8%) were discharged within 72hours while the remaining by the fifth post-operative day. Over 79(95.2%) had complete resolution of symptoms while those with incomplete had underlying morbidities. There was no secondary PTH, blood transfusion or mortality.

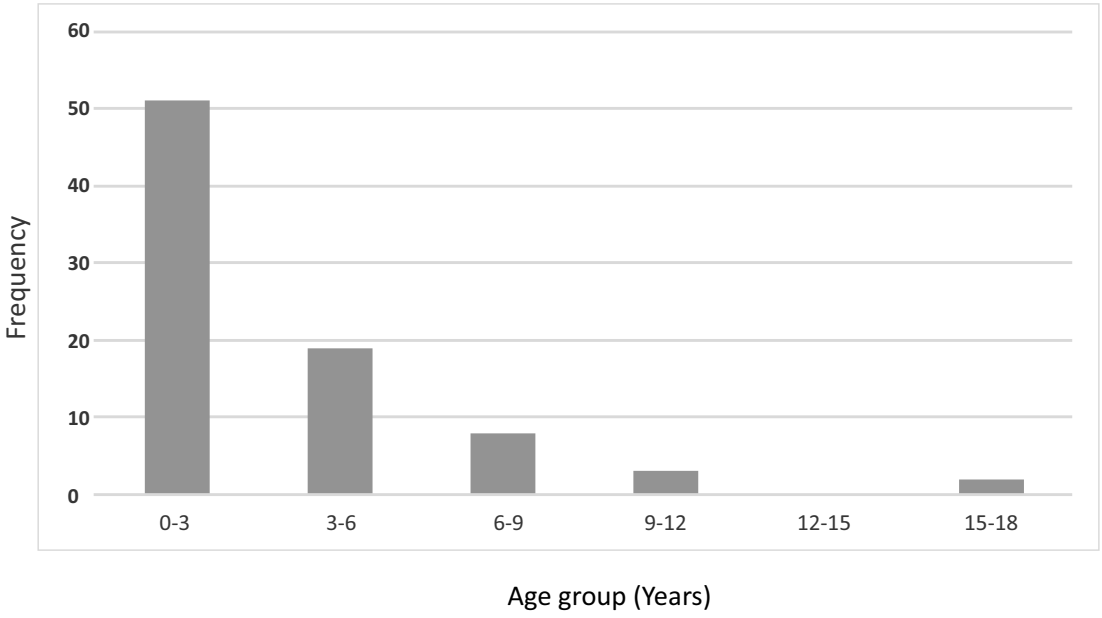

Fig.1; Age distribution of childhood Sleep Disordered Breathing.

Table 1; Grade distribution of Tonsil Hypertrophy

Grade	Frequency	Percent
Grade 1	2	2.4
Grade 2	16	19.3
Grade 3	39	47.0
Grade 4	26	31.3
Total	83	100.0

Table 2; Summary of descriptive statistics of main variables in Childhood SDB

	Minimum	Maximum	Mean	Std. Deviation
Clotting profile (INR)	0.52	2.68	1.23	0.26
Clotting profile (PTR)	0.58	1.92	1.23	0.23
Estimated blood loss (ml)	10	250	43.04	32.82
Adenoid vol(ml)	0.2	4.5	1.56	0.83
Tonsil vol(ml) (Right)	1.0	6.0	2.67	0.99
Tonsil vol (Left)	0.8	4.0	2.58	0.98

NB: For volume of surgical specimen by Archimedes' principle; 1ml=1g

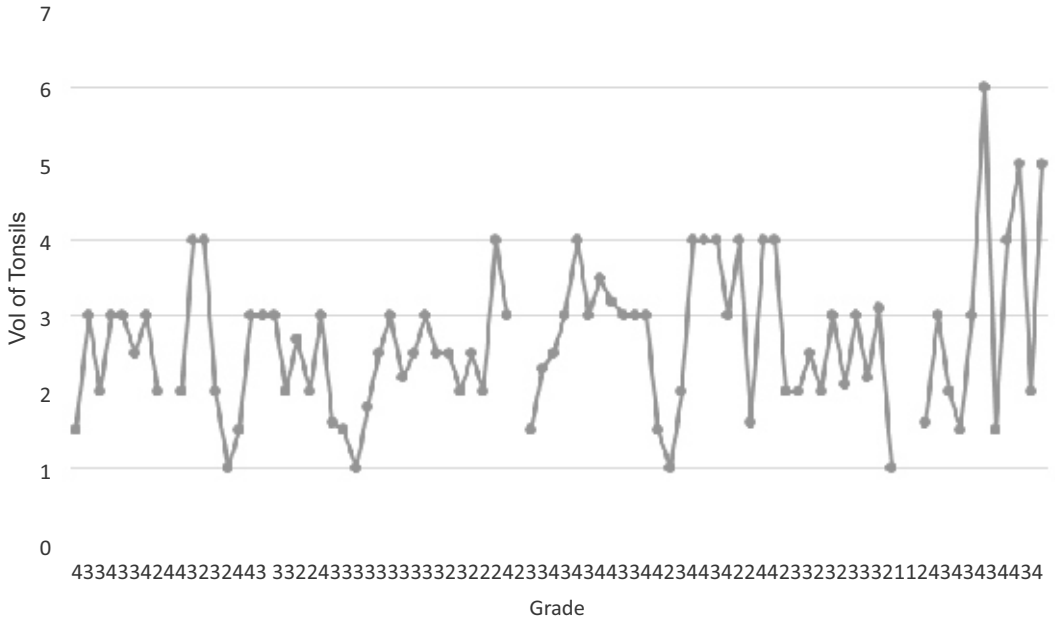

Fig. 2 Relationship between Brodsky's Tonsil grade and the volume of surgical specimen in childhood SDB. Pearson coefficient of correlation(r) = 0.388, p = 0.0001 at 99% CI.

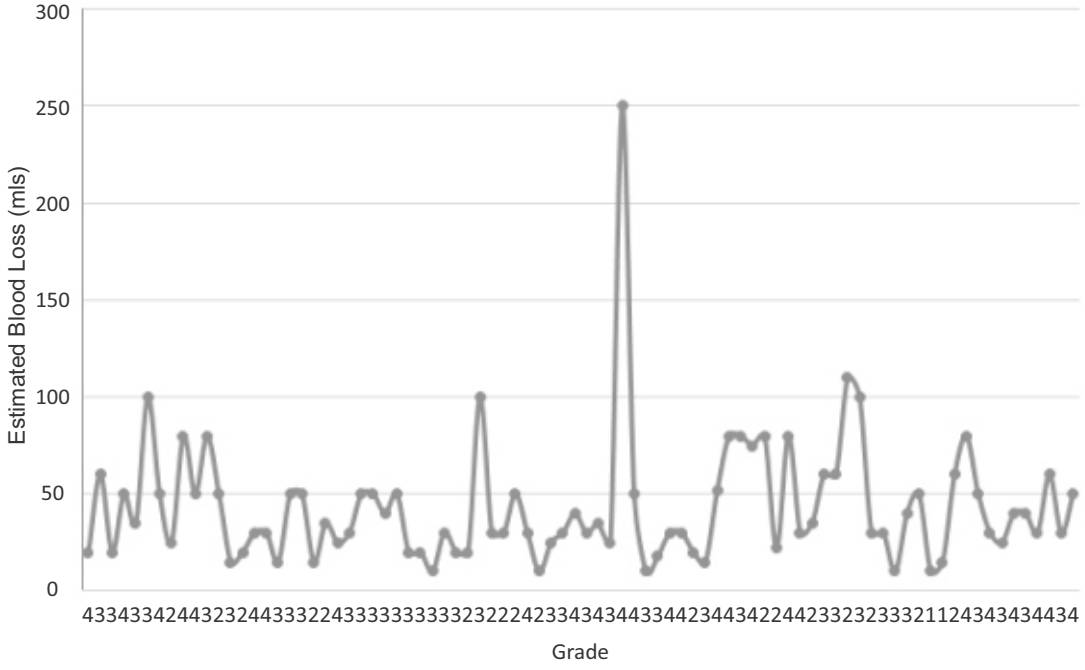

Fig. 3. Association between Brodsky's tonsil grade and volume of blood loss in Childhood SDB. Pearson Coefficient of correlation(r) = 0.217, p = 0.048 at 95% CI.

Discussion

Prevalence of SDB has been estimated at 2% and 4% in women and men respectively, in the general population and between 1% and 4% in childhood[25-29] which is consistent with the 2.8% in our study. We found that Childhood SDB was more frequent in the 2nd birth order with no clear scientific explanation, however, genetic factors have been implicated in paediatric SDB.[26] Childhood SDB exhibits a bimodal age distribution at ages 0-3years and 3-6years, equally reported in our series; and observed as the age of disproportionate proliferation of the adenoid/tonsil lymphoid tissues in response to viral infections, cigarette smoking and or allergy. The adenoids regress by age 7years whereas tonsils persist in life.[13,29,30] The spectrum in this study is snoring, noisy breathing, OSA and OSAS which are easily obtained from history.[12,31] However, parameters such as UARS, OSAS, Respiratory Event Related Arousal (RERA), Respiratory Disturbance Index (RDI) and Apnea-Hypopnea Index(AHI) are diagnosed by overnight polysomnography (PSG) often unavailable due to cost and expertise. The hallmark of SDB which are snoring, nasal obstruction, mouth breathing and apnea are obtainable from bedmates as reported.[32] Similarly, OSAS hallmark which are snoring, sleepiness and apnea can be determined clinically.[25] Accordingly, OSAS severity is evaluated by the Sleepiness Severity Score using the Epworth's Sleepiness Scale Score and Multiple Sleep Latency Test which are clinically obtainable.[2,33-36]

Though overnight PSG is the gold standard for assessing SDB severity, it has been reported that history and examination can predict OSA in 50% of patients as practiced in our institution.[37,38] Snoring severity score and BMI have been found to be the two most accurate predictors of OSA which snoring severity was the most predictive.[12,33,35] This is a recommended approach to SDB research in resource-constraint settings.[39]

Snoring, a marker of SDB, often indicates an underlying pathologic change.[14,36,40,41] Snoring was the predominant symptom in all participants of this study, the intensity of which has been found to positively correlate with OSA(S) and AHI severity.[1,33,42] The intensity of snoring is dependent on the degree of obstruction; and obstructive adenotonsillar disease has been reported a major risk factor in childhood SDB.[43,44] A constellation of snoring, nasal obstruction, rhinorrhea and mouth breathing are almost pathognomonic of obstructive adenoidal disease.[3,11,27] "Adenoid facies", a major feature in a study with 75%[11] accounted for 1 in 25 in this study. This presentation may require the orthodontic physicians reverse with surgery.[45,46]

The severest form of SDB, characterized by partial or complete cessation of breathing leading to hypoxia, occurring several times during sleep from pharyngeal obstruction is OSA.[3,47-49] In early 1990, simulation of OSA in rodents using cyclic hypoxia was shown to produce gradual development of hypertension thereby initiating research into the long-term cardiovascular implications of OSA.[16] A study on SDB reported REM OSA to be causally associated with hypertension. Apnoeic episodes predominantly occur during REM sleep where cholinergic-mediated inhibition of the hypoglossal nerve results in the suppression of genioglossus muscle tone, which increases the propensity for upper airway collapse.[50] An 8-year prospective study, provided a compelling evidence of a 3-fold increased risk of

ischaemic stroke in OSA patients, a second leading cause of death globally.[51] We recorded a fifth with OSA where OSAS accounted for approximately half. Cardiopulmonary complications were observed in a third; reported to increase deaths, disability and healthcare costs.[52] The mechanism involved is via episodic hypoxia and arousal, with the generation of free oxygen radicals which trigger sustained autonomic activation and endothelial dysfunction with pulmonary or systemic hypertension as accompanying consequences.[27,50,53,54]

Inflammation associated with OSA contributes to the increased resistance, particularly at the adenotonsillar level. In adults, oedema and inflammatory cell infiltration were observed in surgical specimens.[27,53-58] This was similarly reported in all the histopathological specimens in our study in children. Accordingly, systemic inflammation may be responsible for the fever experienced by more than a third in this study; a source of chronic ill-health with frequent hospital visits. Furthermore, this study recorded 1 in 17 of the participants with failure to thrive which defective release of growth hormone, whose secretion occurs in stage 4 of NREM sleep being implicated.[14,15] However, several other factors such as dysphagia, odynophagia, anorexia and increased catabolism have also been speculated to be responsible as recorded in this study. We hypothesize that the increased circulating inflammatory cytokines such as TNFα, IL-1, 6 and λIF that are associated with OSA[1,16,29] termed 'cachexin', similarly described in the pathogenesis of wasting in chronic ill-health and tumor cachexia to play a role.[59-61] This phenomenon may require further study to establish this theoretical postulation. Poor academic performance, which is multifactorial was observed in 1 in 25 which is mainly a consequence of hypoxic injury to the frontal lobe/prefrontal cortex from repeated bouts of ventilatory overshoots and undershoots. Rapid eye movement (REM) sleep deprivation has been speculated to affect memory.[1,12,15,16]

The localization of the region of obstruction is crucial in determining the appropriate surgical approach for SDB which prompted Tvinnereim and co-worker to develop the Apnea graph in 1992.[62] Consequently, apnea graph has been reported as a convenient, reliable, cheap and simple technology for SDB study.[63-65] This may improve SDB management in low income nations who, at present, rely on clinical acumen in the diagnosis. First line therapy for childhood SDB remains T&A as performed in our series also widely reported.[66-67] All had perioperative antibiotics, in agreement with a recent report where bacterial biofilms were isolated in surgical specimens[68] though AAO-HNS 2011 guidelines suggest otherwise.[69]

There was a positive correlation between tonsil grade and volume of surgical specimens in this study and between volume of surgical specimen and blood loss as similarly reported in the general population in a study recently.[70] This may bring new insights in T&A to predict the extent of surgery to curtail incidents of primary PTH frequently experienced from excessive, partial or suboptimal removal.[24,71,72] Post tonsillectomy hemorrhage is a source of mortality in T&A and a leading cause of litigations in Oto-laryngological practice.[70.73,74] This occurred in 2.4% in this study. The median duration of surgery in this study was 48mins which was shorter compared to that in adults as recently reported due to fibrosis and difficult dissection.[70]

There is a five- fold chance of developing airway complications post T&A in childhood SDB with OSA during induction and emergence from general anesthesia.[75] 'Awake' extubation rather than 'deep', where all reflexes may have returned to prevent laryngospasm often triggered by blood/secretions was our strategy as recently reported.[76] Laryngospasm which carries high mortality is a complication to anticipate post T & A of which Suxamethonium is a useful remedy.[77,78] Almost all patients were discharged after 72 hours, the period reported most critical for PTH in > 80% [79--82] responsible for the authors' reluctance for Day Case tonsillectomy. Complete resolution of symptoms was recorded in almost all save those with underlying premorbid conditions. Lack of polysomnograpghy and apnea graph for full objective evaluation, multiplicity of surgeons and small sample size are limitations of the study. However, this may serve as a foundation for a renewed interest in Sleep Medicine, particularly in the developing nations where the subspecialty is still rudimentary.

Conclusion

Childhood sleep disordered breathing is not uncommon with snoring as the frequent feature. Obstructive sleep apnoea syndrome which correlates snoring severity accounted for half of Obstructive sleep Apnoea patients. Cardiopulmonary complications are common, making comprehensive pre-operative evaluation necessary to avoid surgical adverse events.

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