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Long-term follow-up and mechanisms of Obstructive Sleep Apnea and related syndromes through infancy and childhood

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Abstract

Background: Although tonsil and adenoid (T&A) enlargement in children is a leading cause of it, OSA may occur at any age. However, even after T&A surgery, some children experience recurrent apneic episodes. The reasons for possible recurrence are unclear. *Objective*: To quantify the prevalence of recurrent OSA after T&A surgery and find out a common cause of OSA in children from the neonatal period to adulthood. *Method*: A retrospective report of apneic patients followed in a tertiary-care center is presented. Telephone interviews of parents were performed 3 years after T&A surgery. The questionnaire included night and day symptoms related to sleep-disordered breathing (SDB). A literature review was performed about associated causes of upper airway stenosis. *Results*: Out of 59 children who were included to follow up, 5 (8.5%) experienced residual or recurrent symptoms of SDB. The literature suggests the role of skeletal abnormalities in this process through nasal or pharyngeal stenosis. Major craniofacial anomalies are a well-known cause of obstruction. Thickened soft tissue has to be ruled out. Minor stenoses or neuromuscular disorders are less often diagnosed although they seem to be involved as well. *Conclusion*: A longitudinal follow-up of apneic children is able to reveal recurrence of SDB after adenotonsillectomy and often allows the understanding of mechanisms of upstream-induced recurrent pharyngeal obstructions.

Keywords: Obstructive Sleep Apnea; Sleep-disordered breathing; Adenotonsillectomy; Craniofacial anomalies

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1. Introduction

Obstructive Sleep Apnea (OSA) occurs during the whole pediatric age. Any child, from the neonate to the adolescent, may experience this major syndrome, although it is most common in preschool children, especially those with enlarged tonsil and adenoid (T&A). Its actual prevalence (ca. 2–4%) is difficult to measure because it is widely underdiagnosed. It is considered by pulmonologists to occur one third as often as asthma [1].

OSA is dangerous and insidious because it leads to daytime sleepiness, chronic fatigue, systemic hypertension, behavioral problems, sleep walking, sleep terrors, confusional arousal during sleep, neurocognitive deficits, pulmonary hypertension or even (fortunately rare) sudden death [2,3].

Historically, the first sleep breathing disorders were reported by Gastaut (see Ref. [14]) in obese patients, who he called ''Pickwickians''. In 1972, Guilleminault was the first to publish reports of normal-weight snorers with abnormal breathing during sleep and abnormal blood pressure. He introduced the OSA syndrome. In 1973, Guilleminault reported on children with OSA and high blood pressure and their cure by a tracheotomy. The relationship between sudden infant death syndrome (SIDS), apparent life-threatening events (ALTE) in infants and OSA in prepubertal children was demonstrated by the same author in 1976 [4].

Obese adult patients have impaired diaphragmatic functioning and thus use their accessory muscles. Since accessory muscles are less active during REM sleep, the upper airway becomes partially or completely occluded, resulting in important drops in oxygen saturation (SaO_2) with associated apnea or hypopnea. Of course, any added nasal edema is poorly tolerated.

In the early 1980s, investigations using esophageal pressure (PES) measurement and oronasal flow showed that abnormal increase in respiratory effort without apnea and hypopnea could also occur in normal-weight adult snorers, which led to the recognition of the upper airway resistance syndrome (UARS) in the 1990s. It soon became evident that this syndrome could occur in non-snoring people in which case drops in SaO_2 may be much less in REM sleep. Interestingly, in spite of abnormal increases in respiratory effort or breathing frequency (tachypnea) during sleep, some children and most women may even have a normal nocturnal SaO_2 [4].

Subsequent investigations including morphometric and cephalometric analyses have identified individuals who are exceptionally obese and also have craniofacial anomalies (including ''long-face syndrome''). These patients predominantly present sleep-related airway occlusion behind the base of the tongue in association with a small airway space when awake. Their complaints usually begin in young adulthood. It would be interesting to consider whether their symptoms frequently occur earlier.

In infancy and childhood, the most common cause of OSA is tonsil and/or adenoid enlargement. However, some patients seem to receive only partial relief from T&A surgery. Of course, operative insufficiencies (such as incomplete removal of lymphoid tissue) or persistence of other medical factors such as nasal allergy may be responsible for residual resistance or recurrence of the disease. There are also patients that present residual nasal or nasopharyngeal obstruction despite elimination of the enlargement of lymphoid tissue.

Thus, our questions were as follows. How often do such cases occur, and what are the reasons of these problems?

2. Method

In a Parisian pediatric university hospital, a telephone survey was conducted during the summer of 2002 in families of children having undergone T&A surgery for clinically noted upper airway obstruction in 1999.

A brief questionnaire was used to check for the perceived quality of sleep by parent(s) and to search for a possible relapse in symptoms of sleep-disordered breathing (SDB). This questionnaire included questions to parents and children about the existence of snoring, parasomnia, daytime sleepiness, performance of school activities and growth anomaly. After the questionnaire was completed, parents received counseling about a follow-up visit to their pediatrician or family physician in case of persistent or recurrent symptoms of SDB.

3. Results

Of 63 patients records found, 4 were lost to follow up. The studied population thus consisted of 59 children, 26 girls and 33 boys. At the time of surgery (1999), their mean age was 5.02 years (range: 2–15).

About 3 years later, according to interviewed parent(s), five patients (8.5%) still chronically snored at night. In relation to sleep disturbances, no significant daytime symptoms were reported in this cohort. Patients with nocturnal chronic snoring were invited to consult their pediatrician or general practitioner.

4. Discussion

Many children experience SDB, which includes OSA, obstructive sleep hypopnea and UARS. The diagnosis of SDB is essential to avoid any impairment in the development of a child. Physical and neuro-cognitive deficits have been described in relation to all forms of SDB. Thus, SDB should be ruled out in cases of apparent life-threatening event (ALTE) in newborn and young infants, failure to thrive in infants and children (for which OSA has been shown to be a cause), heart failure, fatigue, daytime sleepiness and bruxism (increased with stress and malocclusion). The report of sleep noise or observed apnea by parents or relatives should also lead to diagnostic procedures. Many reports also emphasize the importance of the abnormal behaviors, including fragmental sleep with crying spells (infants ‘‘who do not sleep’’), sleep terrors, sleepwalking and confusional arousals. Recently, a correlation was confirmed between hyperactivity/attention deficit syndrome (HAAD) and SDB [5]. Abnormal aggressiveness or shyness may be also related. Last but not least, acquisitions delays and behavioral difficulties at school are considered as a huge but hidden consequence of SDB in children of all ages. SDB should be considered a major public health and educational concern on a national scale [6].

Therefore, signs and symptoms that have been related to SDB must be investigated by every pediatric health care provider. Questionnaires such as Brouillette et al.'s [7], or Chervin et al.'s [5] are designated to obtain maximal information from parents and child about his/her nocturnal and diurnal behavior.

These questionnaires have been developed in light of diagnostic difficulties related to most forms of SDB. Polysomnography is a comprehensive sleep study that may be both expensive and of limited accessibility in several countries. A clinical score based on the use of a detailed questionnaire is extremely useful for the approach of a precise diagnosis. Such precision is even more necessary in the case of a post-surgical examination. Time and patience are necessary to obtain detailed information. Even simple but chronic snoring is considered as abnormal in a pediatric population. After T&A surgery for airway obstruction, families and physicians tend to neglect strict clinical follow-up (or a sleep study) due to the high rate of improvement. Since 1989, however, several studies have demonstrated the persistence of SDB in children and teenagers who underwent T&A surgery. Guilleminault et al. [8] showed that recurrence of apnea was seen at puberty despite T&A before 8 years of age. In a pediatric longitudinal cohort study of SDB cases in Cleveland, Morton et al. [9] found a higher proportion of abnormal apnea/hypopnea index in children who previously underwent T&A surgery than in the non-operated population. They claim for the need to follow children post-T&A. More recently, another study confirmed that removal of T&A was not the perfect treatment for eliminating the risk of residual or recurrent SDB: Tasker et al. [10] studied the sleep profiles of 20 teenagers who underwent T&A removal for demonstrated apnea 12 years before the study. They compared the profiles to sleep study data of 20 control patients. A significant difference was found: 50% patients versus 20% controls reported snoring, 80 versus 31 mean number of snores per hour and higher inspiratory effort in the patients. This information leads to consider other causes of airway obstruction in a significant number of patients who undergo T&A surgery for SDB. Our current study presents similar results as those of Tasker et al. As Tasker et al. stated, "A narrower upper airway... persists...and may partly account for the occurrence earlier of preoperative sleep apnea while T&A hypertrophy was present".

In obese adult and teenage patients, thickness of soft tissue surrounding the airway (pharyngeal lateral and posterior walls, base of tongue, soft palate and cheeks) is involved in SDB by narrowing the air passage. In non-obese patients without any space-occupying soft tissue mass, only the skull and face skeleton are responsible for airway obstruction. "Definitely skeletal and particularly maxillar and mandibular positions play a key role in dictating the size of the upper airway". [4] This is quite obvious in cases of craniofacial anomalies well known for inducing severe OSA. Mandibular abnormalities, such as those found in Pierre Robin sequence, Treacher-Collins/Franceschetti and Goldenhar syndromes and in other hemifacial "microsomy," induce tongue obstruction along with other mandibular hypoplasia and tongue hyperplasia (e.g., Wiedemann–Beckwith, Trisomy 21, mucopolysaccharidoses, etc.). Maxillar abnormalities are found in Apert, Crouzon and Pfeiffer syndromes, achondroplasia and other forms of maxillar retrusion.

Apart from these syndrome abnormalities, some isolated major or even minor mandibular or maxillar anomalies may be found. Genetics of the craniofacial development are intimately linked to SDB. Some authors previously noted that black children are more

prone to airway obstruction [11]. In 1997, Redline et al. [12] found that African–Americans were at greater risk for OSA and a greater severity of it. Moreover, Li et al. [13] demonstrated the occurrence of more severe OSA in Far-East Asian adults. Morton et al. [9] found that black children were less likely to have undergone T&A but more likely to have SDB after surgery. A genetically predisposing factor is thus suggested. Ethnicity appears as one of the determinants of the size of the airway.

Recently, Gaultier and Guilleminault [14] reviewed current findings on craniofacial differences between ethnic groups. They recalled that Caucasians are usually ''dolichocephalic'' (with flat cranial base, protrusive maxilla), whereas Africans and Asians are more commonly bradycephalic (round, large skull and retrusive maxilla). However, some subjects are retrognathic and other prognathic in most ethnic groups. Genetics cause minor skeletal variations that may lead to small upper airways. This likely includes nasal/nasopharyngeal stenosis via some degree of maxillar hypoplasia (anteroposterior and lateral narrowing), flattening of skull base (vertical narrowing) and also oropharyngeal stenosis via maxillar hypoplasia (lateral narrowing) and mandibular hypoplasia (anteroposterior narrowing). Of course, such minor abnormalities are often difficult to demonstrate. For example, in the case of SDB in a neonate with obstructed nose (so-called neonatal ''rhinitis''), ascertaining a normal or abnormal size of the upper airway is highly difficult. A piriform aperture stenosis and a high arched hard palate favour the hypothesis of narrow maxillar hypoplasia. In most cases, however, a precise diagnosis is difficult. Attempts to evaluate the size of a normal airway at this early age must be encouraged [15].

Asserting the site of obstruction is also a difficult task. According to many authors, imaging of the airway during artificial sleep (general anaesthesia with spontaneous ventilation) or natural sleep is the key to finding the cause of obstruction. Use of thin flexible scopes, videofluoroscopy and MRI has been advocated. Special techniques or devices have even been suggested for this task [16]. The result of these procedures is to showing vibration or obstruction at the soft palate or the tongue base levels. However, these locations cannot be asserted as the origins of the disorder. According to Bernoulli's principle, the pressure decrease in the narrowed parts of the airway results in suctioning of its walls, expressed through vibration of some structures and displacement of lateral structures toward the midline. This movement occurs both at the narrowed region and, especially in case of rigid structures at the point of narrowing, downstream, where soft tissues are present. For example, a narrowed nasopharynx may result in the suction of palatine tonsils or tongue base. It is likely that apparent sites of obstruction through direct imaging are not the only causes of respiratory problems. This has obvious consequences on the treatment of SDB cases. If the occurrence of upper airway resistance due to even minor primary skeletal abnormalities must be emphasized, attention to secondary facial stenosis is also advocated by many authors. Airway obstructions can result in skeletal, dental and muscular alterations. SDB-induced facial skeletal anomalies have been demonstrated in animals, whenever they are caused by depression in the airway or by peculiar postural responses in obligatory oral breathers [17–19]. The ''long-face'' syndrome and some cases of mandible ptosis are likely consequences of mouth breathing. This can be due to T&A enlargement or minor primary bony airway stenosis associated with nasal mucosal edema. This is especially frequent in children with local or general

hypotonia as found in cases of neuromuscular disorders, neurological impairment and cerebral palsy. These deformations often lead to worsened SDB.

Clinicians should thus be aware of the importance of detecting minor craniofacial abnormalities (isolated or in association with nasal obstruction such as in case of chronic rhinosinusitis) that persist or worsen with age. These abnormalities include: (i) ''long-face'', mandible retrusion or ptosis, (ii) nasal/choanal stenosis with maxillar hypoplasia and (iii) nasopharyngeal stenosis (vertical or lateral with associated oropharyngeal stenosis as seen by close posterior pillars).

Furthermore, considering that some children experience UARS from birth and that a continuum has been demonstrated from simple snoring to OSAS in adult patients [4], the possibility of a continuum of UARS between infancy and adulthood should also be considered.

5. Conclusion

Adenoids then tonsils (due to pharyngeal aspiration below the nasopharyngeal stenosis) are first causes of OSA in pediatric patients. However, other causes must be outlined. Major craniofacial anomalies are easy to diagnose. Minor craniofacial anomalies are subtle but may lead to prolonged SDB with general and neurocognitive consequences. In this matter, lateral stenosis is less frequent than AP stenosis and more difficult to detect. SDB must systematically be checked by questionnaires and/or sleep studies in children, especially those who have undergone T&A surgery for airway obstruction.

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