Paediatric Sleep Disordered Breathing

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Core messages

History and examination is essential. Sleep polysomnogram is necessary if routine procedures do not correct the problem. Diagnosis directed pharyngoscopy is important in determining level(s) of obstruction. Improving the nasal sinuses may improve the sensation of nasal airflow, changing the child's preference of breathing, hence changing the site of collapse. Variations of the adenotonsillectomy technique may have to be considered in correcting sleep disordered breathing. Countinuous positive airway pressure (CPAP) and tracheotomy continue to play an important role in the overall management of multilevel obstruction in a pediatric airway.

Contents

Introduction

"Non-restorative sleep" as coined by Rohde and Verse has become an epidemic in the last century, in our increasingly competitive society. Without good quality sleep, problems of diminished intellectual performance (58%), personality changes (48%) and nocturnal enuresis (30%) have been highlighted [1]. According to the international classification of sleep disorders of which there are 95 different diagnoses, the one major subgroup that interests ENT surgeons is obstructive sleep apnea syndrome (OSAS) (780.53-0). Children who have OSAS usually present with snoring. If left untreated, this may impose long term adverse effects on neuro-cognitive and cardiovascular function [2]. Beebe (2006) highlighted concerns in attention deficit, abnormalities of general conceptual abilities, school grades, arithmetic skills, IQ, memory and hyperactivity to name a few [3]. Rosenfeld (2004) emphasized the effect of OSAS on behaviour, causing changes such as externalizing, emotional lability, somatic complaints and social problems [4]. Spectroscopy has demonstrated changes in the hippocampus and frontal region of the brain[5], whilst chronic upper airway obstruction puts the child at risk of developing impaired facial growth, sinusitis and asthma.

Evaluation

Mitchell (2006) reported that up to 50% of pediatric visits to ENT surgeons are for upper airway obstruction and that history is the most common method of diagnosing OSAS [6]. By definition, OSAS involves the reduction or cessation of oronasal airflow despite ongoing respiratory effort for a minimum of two breath cycles. The symptoms that classically characterise this condition include snoring, restless sleep, unusual sleeping positions, witnessed apneas and mini-arousals. When symptoms are more severe, the parents may report nocturnal sweating, enuresis or severe behavioural changes. Attempts to categorize children based on the presence or severity of disease with questionnaires and/or clinical scores have proven to be of limited value, but they at least focus the physician and the parents on what they should be looking for. A study using the Pediatric Sleep Questionnaire scored better than the Brouilette score, and the results demonstrate a sensitivity of 81% and a specificity of 87% for diagnosing OSA [7].

The current gold standard for diagnosing OSA in children is an overnight sleep study or polysomnography (PSG). The primary result is the number of respiratory events per hour, reported as the respiratory disturbance index (RDI) or the apnea-hypopnea index (AHI). The percentage of Oxygen saturations (SpO2) below 90% and an elevation of the end-tidal carbon dioxide (ETpCO2) are important in determining the whole picture. Overnight polysomnography (PSG) has been used preoperatively in 10% of cases in our hospital network, but the waiting times for this study in Australian pediatric centers exceeded 6 months in many cases. There is always the question of reproducibility of sleep studies, and to date, 84.6% of cases are generally correct [8]. I personally think that any single investigation only allows the physician to see the patient's condition for a certain window in time, and it is the complete evaluation that determines the final diagnosis.

The most common physical features we examine for include the size of tonsils and adenoids, as they reflect the airway dimensions important in defining the risk of OSA. However, airway changes associated with conditions like allergic rhinitis, Down Syndrome and neuromuscular hypotonia are important too. Physicians and surgeons that manage children with OSAS need to undertake risk assessment for the individual whose treatment they are planning. Allergic rhinitis is associated with an odds ratio of 5.27 for OSA [9], and it emphasizes the Starling resistor theory that in any tubal structure, the airflow pressures able to be generated prior to the collapse of the area determine the critical closing pressure at the site of obstruction. MRI studies suggest that the site of maximal airway obstruction is the retropalatal region where the adenoids and tonsils overlap [10].

A literature review of the experience gained in the last twenty years has seen a change in approach that depends on the site of obstruction. Evaluation has allowed the site of obstruction to be better appreciated. The obstructed airway can involve any area from the nasal tip to the carina, and often there is more than one area of narrowing. OSAS is the result of a complex interaction of the musculoskeletal constructs of this airway and the other soft tissue and lymphoid components that may impinge from within or from outside the airway.

Sleep endoscopy was introduced to complement the evaluation of OSAS.

Using a flexible endoscope, a child is sedated or anesthetized, and has his/her airway assessed. It is currently the only evaluation that can demonstrate the obstruction at the level of the supraglottis and base of tongue. If the problem is at the velum, the area prior to the velum and at the velum is critical; hence the success of the operation for adenotonsillectomy. If the area is at the laryngopharynx, especially in the patient that mouth breathes, surgery to remove the tonsils also works. However, if the lingual tonsils or tongue base still is critically narrow, surgery to this area may be required.

Continuous positive airway pressure (CPAP)

CPAP is an effective method of relieving airway obstruction, and works on the principle of using a continuous flow of high-pressure air as a support for maintaining a patent airway. The mechanism involves filtered room air being delivered under pressure via a mask into the patient's nasal passage. The positive pressure of the delivered air counteracts any negative pressure that would otherwise cause the airway to collapse, ensuring that the airway remains open while the machine is in use [11]. The pressure required to overcome obstruction and achieve a patent airway differs based on each individual. However, for babies, pressures are commonly between 3.5-6 cmH2O [12].

CPAP has been validated as an appropriate method of relieving obstruction in children for over 20 years [13]. Waters et al. (1995) found that the use of CPAP in a population of 80 children with OSA (aged between two and fifteen years) reversed pathological breathing patterns, and in addition, appeared to improve the secondary complications of OSA in this group [14]. Airway obstruction was assessed using a combination of PSG and parental questionnaires. Another major benefit of the use of CPAP is that once treatment has been established, babies can be managed in their own homes rather than in the hospital setting [12].

However, CPAP is a temporising measure and given the poor rate of compliance in the long term, surgical curative options continue to evolve. It has always been a concern that the child is "too young" for surgery. However it is with the knowledge that many of the uncorrected children will go on to develop the full OSAS with its associated cardiovascular and neuro-cognitive complications that there is now an increasing push for treatment to be considered earlier. Our own Australian statistics confirm that 10% of children snore and that 2-3% snore and have significant OSAS. Only 0.5% of Australian children have adenotonsillectomy for OSAS. In our experience at the Children's Hospital in Westmead, Sydney, amongst 61 children reviewed, 42.6% were recommended for surgery, 23.1% needed preoperative CPAP and 6.6% required postoperative CPAP. At 12 months following recommendation, only 65% of those recommended towards surgery had done so; emphasising the need for continued follow-up[15].

Nasal surgery

Beginning at the nasal tissues, it is important to define the intraluminal obstruction by nasal turbinates, septal tissues, and congenital anomalies such as pneumatised middle turbinates. There are many other unusual conditions involving the nose, but long term rhinosinusitis often leaves a child mouth breathing because of the discomfort of nasal breathing. The management of the sinuses in the child is still controversial, and the techniques of medical and surgical intervention vary from year to year. However, by mouth breathing, the dynamics of the pharyngeal airway is changed, and this in turn predisposes the child to sleep disordered breathing. This may not cause significant oxygen desaturations, but the parents frequently complain that their child is a restless sleeper and the child frequently complains of an unsatisfactory sleep pattern. Hence there has been a gradual push to improve the quality of nasal breathing, with newer techniques including the use of **balloon sinuplasty** [16], limited careful dissection of the ostiomeatal complex to allow better mucosal flow, and controlled ablation of turbinate tissues using plasma technology. Research continues into the use of topical steroid therapy, the use of topical douching solutions and anti-inflammatories specific to mucosal disease of the nasal airway tissues.

Nasopharyngeal surgery

Adenoidal obstruction is one of the commonest causes of obstructive sleep apnoea and surgical correction has low morbidity and satisfactory outcomes in most situations. However, incomplete resection has been the cause of many unhappy visits to the ENT practice. Currently the use of either indirect visualization with a dental mirror or the use of fibreoptic nasendoscopes is paramount to a successful clearance. Occasionally, recurrences occur when there is residual lymphoid tissue, but this reflects ongoing immunological stimulation by forces such as allergy and infection. The adenoids could be removed using curettage, microdebriders, coblation, harmonic scalpels or suction diathermy. However, the need for vigilance for velopharyngeal incompetence in the undiagnosed submucous cleft palate patient or child with medialized carotid vessels cannot be under-emphasized.

Tonsil surgery

Surgical ablation of the tonsils often reduces the constraints to the respiratory airway, but how they are removed continues to elicit hot debates. As Mink et al (2009) remarked, there are at least nine different dissection techniques, three described planes of dissection, eight methods for hemostasis and 41 different outcome measures [17]. There are now complete tonsillectomy techniques, partial tonsillectomy techniques and tonsillotomy techniques. In the adult literature,regarding only the management around the soft palate to correct "velar collapse", there is the standard adenoidectomy, uvulopalatopharyngoplasty, uvulopalatal flap, laser assisted uvuloplasty, extended uvuloplasty, palatal stiffening procedures and uvulectomy.

In performing tonsillectomy to correct sleep dysfunction, the surgeon is firstly removing the bulk of the tonsil tissue itself. Secondary effects include the subsequent cicatrization which improves the velopharyngeal airway by ventral displacement of the posterior pillars and reducing lateral pharyngeal collapse during inspiration. In certain cases, excess posterior pillars require a sphincter pharyngoplasty approach as advocated by Pang and Woodson (2009), whilst a uvulopalatopharyngoplasty reduces the impact of the uvula on the posterior pharyngeal wall [18].

Lingual surgery

Retroglossal collapse has become the next frontier in dealing with pediatric OSAS. There is surgical research into performing better tongue reduction surgery using the radiofrequency base of tongue (RFBOT) approach, Submucosal Minimally Invasive Lingual Excision (SMILE), thyrohyoid suspension, epiglottic repositioning procedure [19], partial epiglottectomy, and variations of supraglottoplasty with and without lasers. More recent advances in tongue channelling surgery provides the surgeon with another option with which to treat relative macroglossia as seen in Down syndrome and Beckwith Wiedemann children without more mutilating tongue reduction surgery that was previously the norm.

Coblation technology uses bipolar radiofrequency to create "plasma" that potentially allows precise clearance of tissues at low temperatures of 40 to 70 degrees Celsius[20]. Using saline to create an ionised gas with sodium radicals, it causes molecular disassociation with a thermal penetration of less than 125 microns. Greene (2008) examined his figures with this technology on over 250 patients for base of tongue surgery with a six month to five year followup, finding it to have minimal complications [21]. However long term studies are still required.

Surgery to reduce the impact of the tongue base is associated with significant discomfort and a risk of postoperative bleeding causing temporary but serious airway compromise. I believe the key is still being cognizant of these possibilities and taking steps to protect against these complications.

Laryngeal OSA

Laryngeal OSA in the pediatric population occurs most commonly as a result of laryngomalacia but can also be caused by congenital malformations. However, respiratory immaturity also contributes to repetitive apneas especially in pre-term infants. Localized lesions such as vallecular cysts may present as increasing stridor, whilst more central lesions such as an Arnold Chiari malformation are well-known for causing fluctuating apneas in the pediatric population. As a result of our experience with pediatric airway problems, the failure to resolve OSA with simpler measures, such as an adenotonsillectomy, necessitates the examination of the whole airway in a form of "diagnosis directed" nasopharyngolaryngoscopy [19]. Laryngomalacia usually improves with age, but there are numerous case series that encourage the physician to be wary of the "second lesion". In the neurologically impaired child, discoordinate pharyngomalacia continues to a difficult condition to manage [22].

Tracheotomy

Tracheotomy was the first effective therapy for patients with severe OSA, and is more often used for children as they may have malformations that may improve with time, allowing the physician to decide when is the best time to perform corrective surgery. In the adult literature, percutaneous dilating tracheotomies are more commonplace, but they are less often employed for young children because of the proximity of important anatomical structures and subsequently the need to be more precise in one's placement of the tracheotomy tube. Cohen (1998) compared the quality of life of children undergoing other forms of sleep apnea surgery with those experiencing tracheotomies, noting a 59% success rate for sleep apnea surgery compared to a 100% success rate with tracheotomy [23]. However, the impaired quality of life for 95% of the factor analyses with tracheotomised children continues to be the main driving force towards ongoing research to avoid tracheotomy as an initial treatment option. OSA may also occur after the removal of the tracheotomy. Hence, prior to decannulation, the airway needs to be evaluated. PSG has been recognized as an important diagnostic measure preceding decannulation, as unrecognized supraglottic stenosis/collapse or suprastomal granulomata can complicate the removal of the tracheotomy tube. [19-24]

Conclusions

The importance of obstructive sleep apnea as a pediatric health issue is undeniable. Its management is complicated by the multiple variables and the still incomplete understanding of how they affect the overall outcome. Surgeons continue to be at the forefront in research into the management of this condition, in close cooperation with the sleep physicians and other subspecialties.

The keys to unlocking improved management outcomes in the surgical management of sleep disordered breathing in children include being more precise in quantifying sleep outcomes, developing better algorithms in the complete evaluation of sleep disordered breathing, better performance of the precise surgery necessary to correct the anatomical factors that contribute to obstruction and further research into improving muscle tone and wound healing.

In pediatrics, we know we are investing in the future of our society if we can improve the sleep patterns of the younger members of our community. Our work and continuing research into the appropriate management of obstructive sleep apnea is crucial in minimizing the health burden created by sleep dysfunction.

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