

Management Of Obstructive Sleep Apnea In Children

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Abstract

Introduction

Obstructive sleep apnea (OSA) in children is a prevalent condition with long-term implications, well into adulthood. European Respiratory Society (ERS) has defined obstructive SDB as “a syndrome of upper airway dysfunction during sleep, characterized by snoring and/or increased respiratory effort secondary to increased upper airway resistance and pharyngeal collapsibility”. (1,2)

Obstructive sleep apnoea (OSA) is a common paediatric health problem and children at risk need to be identified, investigated and treated in a timely manner because the resultant activation of inflammatory cascades can impose wide ranging effects, impacting on neurocognitive, cardiovascular and metabolic systems.(3) A well-established treatment protocol has not yet been prescribed as it is a multifactorial condition with multiple factors playing an important role in the severity of the condition. The emphasis of this article is to summarize the latest research and developments in paediatric OSA management techniques.

NON INVASIVE MANAGMENT

Continuous positive airway pressure (CPAP)- Several options are available for the medical management of OSA in children. Continuous positive airway pressure (CPAP) is effective in children with OSA. In situations where adenotonsillectomy has failed the treatment of choice is CPAP. CPAP is difficult for approximately 20 percent of children to tolerate. (1) Because children grow rapidly, frequent follow-up visits are necessary, and the mask must be adjusted at least every six months. (1,3)

Weight loss- In obese children, weight loss is an excellent therapeutic measure, but it can be a difficult process. Obesity is the most common etiology detected.(4)

Pharmacological management-There are presently no Food and Drug Administration (FDA)-approved medications for the treatment of OSA in children. **Montelukast**, a leukotriene receptor antagonist used as an adjunctive therapy in persistent asthma, may have some benefit in OSA in which tissue inflammation (particularly of the adenoid tissue) contributes to the obstruction. In select patients, nasal corticosteroids combined with montelukast may be helpful by similarly reducing tissue inflammation and swelling in the nasal passages and adenoids, which can contribute to airflow resistance. (5) In some patients with extreme PAP mask intolerance, which may be due to sensory aversions or claustrophobia, judicious and careful use of anxiolytics or mild sedatives may be warranted, as mask aversion is a major driver of PAP nonadherence in the pediatric population. (1, 5) Some patients with severe SDB and nocturnal hypoventilation may benefit from supplemental oxygen therapy.

Nasal steroid- Nasal steroids should be prescribed temporarily until a referral can be made for treatment. Systemic steroids are used to decrease upper airway obstruction in patients with infectious mononucleosis (because of anti-inflammatory and lympholytic effects). (6) Allergy testing and treatment of rhinitis are important in children with OSA secondary to nasal obstruction.

Antibiotic therapy- If snoring and OSA occur intermittently and are associated with recurrent tonsillitis or adenoiditis, antibiotic therapy may help. Reduction in the bacterial antigen load, secondary reduction in the population of B lymphocytes in the germinal centers of tonsils and adenoids, and the physics of airflow (Poiseuille's law) are such that small changes in airway diameter dramatically affect airway resistance. (7) Reduction of post-infectious lymphoid hyperplasia relieves the obstruction. Even small reductions in adenotonsillar size can eliminate snoring and OSA. (6,7)

INVASIVE MANAGMENT

Adenotonsillectomy remains the treatment of choice for most children with a strong clinical history of OSA or with OSA documented by polysomnography. Anatomically, the tonsils and adenoids represent the most common area of hypertrophy that contributes to airway obstruction. Numerous studies have documented improvement in snoring, OSA, enuresis, behavior, and growth following adenotonsillectomy. (8,9) The AAP guidelines suggest that children with cardiac abnormalities, specifically left or right ventricular hypertrophy, be monitored inpatient postoperatively because they have an increased risk of respiratory complication after AT. (2)

Uvulopalatopharyngoplasty is indicated when a thick soft palate and a long uvula are present. The UPPP procedure is estimated to be only 40% to 50% successful in improving mild to moderate OSA. (10) Its effectiveness decreases over time, adding substantial postoperative complications including velopharyngeal insufficiency (reported at 2%), postoperative hemorrhage (reported at 1%), continued dryness of the airway, dysphagia, voice change (reported at 0.6%), narrowing of the nasopharyngeal walls (reported at 0.8%), and death (reported at 0.2%). (12) Uvulopalatal flap and is actually preferred over UPPP in most cases because it lowers the risk of velopharyngeal insufficiency as it creates a potentially reversible flap that can be altered during the initial postoperative period. (12) Because there are no sutures involved along the free edge of the palate, there is less reported pain in

comparison with UPPP, however, this technique still imposes the same risks of complications as seen with UPPP and is typically performed on adults only. (11,12)

Tracheotomy, the definitive surgery for upper airway obstruction, is reserved for use in children with severe OSA who have failed to improve with other medical and surgical treatments and in special cases in which these modalities are contraindicated or not tolerated. Tracheotomy must be considered in children for whom traditional surgery is unlikely to be of benefit, such as those with Pierre Robin syndrome. (13)

Lifestyle Modification. bariatric surgery may represent a viable therapeutic option to treat OSA in the morbidly obese adult patient,⁸⁰ but the evidence to support its use to treat POSA is sparse. In the systematic review by Ashrafian et al., the authors concluded that both bariatric surgery (19 studies) and nonsurgical treatments for obesity (20 studies) may reduce the effects of OSA by lowering BMI and AHI, suggesting that bariatric surgery results in more optimal improvement in both BMI and AHI, as well as improving the symptoms associated with OSA. (14) Pediatric obesity, a worsening public health issue in the United States, is an independent risk factor for OSA. It is fairly common to see improvement in the AHI with 5% to 10% weight loss. (13,14) Furthermore, longer sleep duration is associated with improved measures of healthy bodyweight, and so optimal control of OSA could help patients to lose weight. (14)

Tongue debulking is occasionally used in patients with significant macroglossia related to syndromes such as Beckwith-Wiedemann syndrome and trisomy 21; however, this procedure is avoided when possible due to the highly vascular nature of the tongue base and the potential for surgical complication. (1)

Mandibular distraction osteogenesis is a relatively invasive but highly efficacious procedure for patients with retrognathia or micrognathia, wherein the mandible is surgically fractured and affixed to an internal device that permits gradual distraction of the mandible at a rate that facilitates bone remodeling. Recent advances in this technique have permitted full internalization of a motorized distraction device in select patients, obviating the need for external pins. (15,16) Magliocca and Helman revealed that maxilla-mandibular advancement of 10 mm was found to be 90% successful in adult patients, average age 41 years, with a BMI <32 kg/m², but was only 60% effective in patients with a BMI >32 kg/m². (15) Patients with significant obesity and severe OSA who underwent bimaxillary distraction osteogenesis of 25 mm showed a 100% effective result in a small cohort of 9 patients.⁷⁸ Again, these studies are limited to adults only. (15)

supraglottoplasty Young infants with upper airway abnormalities may benefit from supraglottoplasty. (17)

Hypoglossal nerve stimulation is a promising intervention, currently under investigation in children, which alleviates airway obstruction due to tongue malposition by applying low-voltage electric pulses to the hypoglossal nerve in concert with diaphragmatic excursion, activating the muscles that move the tongue forward. (17)

DENTAL CONSIDERATIONS-

Oral appliance therapy (OAT)

In 2005, the American Academy of Sleep Medicine (AASM) published updated guidelines that support **oral appliance therapy (OAT)** “as a first-line therapy for mild and moderate OSA”. (18) Once a thorough medical examination is completed by a physician, a dental referral for OAT can be made.⁹⁹ The identification, diagnosis, and treatment of sleep disorders with OAT are areas where both dentists and physicians must work collaboratively for the benefit of the patient. (19) By widening the upper airway with or without lessening the collapsibility of the airway, oral appliances can help improve opening the airway during sleep, which also improves the overall quality of the muscular tone.⁽¹⁹⁾ A clinical trial by Cozza et al. showed that the modified monobloc appliance in children may be considered as an effective approach in the treatment of mild to moderate. (20)

Rapid maxillary expansion (RME), also known as rapid palatal expansion, can be used in the process of expanding the upper airway to alleviate a patient's POSA. In a recent meta-analysis by Camacho et al., the authors found that RME produced a decreased AHI in children with POSA (mean age 6 to 8 years), but can widen the midpalatal suture through the teenage years. (21) In a total of 313 patients, the overall AHI decreased from a mean \pm standard deviation of $8.9 \pm 7.0/\text{hr}$ to $2.7 \pm 3.3/\text{hr}$, resulting in a 70% improvement in the AHI. (21) The authors concluded that patients with smaller tonsil size (Brodsky 1) could benefit from primary treatment of POSA with RME and it could also be used in patients with failed AT in the context of narrow, arched palates. (21) In a cohort study by Villa et al., the investigators report that RME was effective beyond 2 years following treatment in children in whom a combination of malocclusion and POSA was diagnosed. (20) In an older study by Timms in 1974, children treated with RME experienced resolution of nocturnal enuresis. (22) Mandibular advancement and RME are able to improve patient swallowing because they help guide the tongue to the correct position while also counterbalancing the occlusion. (20)

With careful repositioning of the tongue (raising its posture), RME can in return increase the maxillary width and properly seal the lips, which diminishes mouth breathing and the size of the tonsils. (23) Hence, RME is successful in increasing the size of the intranasal cavity by improving the overall oxygen saturation by producing better quality airflow in the nasal cavity; this in turn causes less mouth breathing (particularly in patients with smaller tonsil sizes). (23)

Accordingly, dentists prescribing OAT need to be well versed in pediatric SDB and have an understanding of its diagnostic testing. (14) To determine whether a patient is a candidate for OAT, the dental examination should include a caries risk assessment, periodontal examination, and a temporomandibular joint evaluation to include the muscles of mastication, occlusal analysis, and parafunctional habits, (24) as well as consideration for possible orthodontic evaluation.

A systematic review by Flores-Mir et al. described common findings across various studies to include a narrow maxillary dental arch with a high palatal vault, posterior crossbite, longer and lower anterior facial height, steep mandibular plane angle, clockwise rotation of the mandible, and a retrusive chin to be craniofacial morphological characteristics to be concerned about with regard to POSA. (25) However, there are limitations in diagnosing POSA using cephalometric analysis because of the low resolution caused by soft tissues and the fact that the postural position taken by the patient is not representative of the actual position the patient has while sleeping as shown in a systematic review by Patini et al. (26)

Myofunctional Appliances- Appliances for habits such as bruxism fall under "occlusal guards by report" or "lab occlusal guard-nightguard". Utilizing OAT appliances for myofunctional purposes or bruxism is typically not a current covered benefit for patients, making it difficult for parents to endure an out-of-pocket expense for their child. (26) Myofunctional therapy is an approach that has been used for at least 40 years. It aims to strengthen the muscles of the tongue and orofacial structures by educating patients on how to reposition their muscles to the correct position. (27) Until recently, it is rarely considered to utilize myofunctional therapy in the treatment of POSA, even though there are supporting data pointing to the positive relationships noted between the development of the oropharynx and orofacial muscles that may be collapsing with POSA. (27) Therefore, it would seem that oral myofunctional therapy should be considered a routine part of a comprehensive approach in the treatment of POSA to facilitate in the proper oropharyngeal development of a child. (28) Nasal breathing and lip seal as well as lip tone are factors involved in the treatment by orofacial myologists. (28) Myofunctional therapy includes exercises in nasal breathing, labial seal, lip tone, and tongue posture that can be performed at a repetition rate of 10 to 20 times, three times a day, with the goal of reestablishing nasal breathing and lip seal. (27,28)

ERS TASKFORCE RECOMMENDATION PROTOCOL

The ERS taskforce advises a stepwise treatment approach, until complete resolution of the OSA. This may include a combination of different treatment modalities depending on severity and cause for the upper airway obstruction. The taskforce acknowledges that data on the appropriate sequence of interventions is scarce, but they propose the following steps: (29)

1. **Weight loss** if the child is overweight or obese: there is data supporting the efficacy of weight loss as a treatment intervention in obese adolescents (30). However, there are currently no studies on obese younger children.
2. **Nasal corticosteroids and/or oral montelukast**: children with OSA have increased expression of leukotriene C4 synthase as well as leukotriene receptors 1 and 2 in tonsillar lymphocytes compared with controls (31). Addition of leukotriene receptor antagonists to tonsillar cells from children with OSA in vitro resulted in dose-dependent reductions in cell proliferation and secretion of TNF-, IL-6, and IL-12. A 6 to 12 weeks course of nasal steroids and/or montelukast may reduce adenoidal size and has shown favourable results in children with mild to moderate OSA (5,31);
3. **Adenotonsillectomy**: there is good evidence that adenotonsillectomy is efficacious in children with OSA and adenotonsillar hypertrophy (32). The American Academy of Pediatrics (AAP) recommends adenotonsillectomy as the first line treatment for children with adenotonsillar hypertrophy. Subtotal tonsillectomies, also known as tonsillotomies, have been gaining popularity recently as they have lower postoperative complication rates. However there are no well-designed studies directly comparing the two surgical approaches and their OSA treatment outcomes. Subtotal resection also carries an increased risk of tonsillar regrowth (33). Risk factors for residual OSA include obesity, severe OSA pre-surgery with an AHI of >20/hrTST, children aged >7 years, high Mallampati score, African-American ethnicity, children with asthma, craniofacial abnormalities (e.g., Pierre Robin syndrome), chromosomal abnormalities (e.g., trisomy 21), and neuromuscular disease. (34) Families should be counselled that OSA may recur after initial postoperative improvement; However, a recently published meta-analysis by De Luca Canto et al. has revealed that AT complications, particularly respiratory complications, are more common in children with POSA and even more specifically, children with POSA are nearly five times more likely to develop a respiratory complication following AT. (35) Although AT is considered the first-line surgical therapy, it has proven to have diminishing results in some longterm studies. Studies have revealed that, over the long term, 50% of children with obesity and 10% to 20% of children without obesity will still have residual signs and symptoms of POSA following an AT. (36,37) In children with POSA, a multicenter study by Bhattacharjee et al. showed a 27% cure rate with AT, therefore, this is not a cure-all procedure.10 Moreover, obesity significantly reduces the efficacy of AT in treating POSA. (38)
4. **Rapid maxillary expansion** A Cochrane review concluded that oral appliances are beneficial as an auxiliary treatment in children with OSA and non-syndromic craniofacial abnormalities. However, this review was only based on one study (39). A more recent meta-analysis including six studies concluded that orthodontic treatments may be effective in managing snoring and OSA. The authors noted however, that the efficacy of orthodontic treatments with regards to improving consequences of OSA e.g., neurocognitive and cardiovascular functions have not yet been systematically addressed (40);
5. **CPAP** or non-invasive positive pressure ventilation (NIPPV) for nocturnal hypoventilation: in children who have residual OSA after adenotonsillectomy, OSA related to obesity, craniofacial abnormalities, neuromuscular disorders, those who do not have significant adenotonsillar hypertrophy, or those who choose not to undergo surgery,

positive airway pressure therapy is recommended. Non-invasive PAP. Positive airway pressure has long been a mainstay of non-invasive management in OSA, with the first successful use in children as a tracheostomy-sparing modality described by Guilleminault et al in 1986. (27) The goal is to maintain patency of the upper airway throughout the respiratory cycle, improve functional residual lung capacity and decrease work of breathing. Starting CPAP in children can be challenging, a multidisciplinary team approach works best and parental involvement and education is crucial (27). Once the child has been fitted with the correct size mask, the family is given the mask to go home with so the child can play with it and practice wearing it. Once the child is happy to wear the mask for brief periods of time when awake, an inpatient admission is arranged, nocturnal CPAP is started and pressures titrated. The admission sometimes needs to be for several nights, depending on how the child tolerates CPAP. Play therapists working together with specialist nurses/respiratory therapists, and in the more challenging cases, clinical psychologists, can make the process fun and reduce anxiety. For most children with OSA, CPAP will be effective. However, if the nocturnal CO₂ is significantly raised, which is more often seen in children with other co-existing conditions such as neuromuscular disease, craniofacial syndromes or obesity hypoventilation, BiPAP may be needed. (27) In BiPAP the machine delivers a higher inspiratory pressure when the child breathes in, and a lower pressure when the child breathes out. BiPAP may also be better tolerated in children who do not tolerate CPAP due to high positive endexpiratory pressure requirements. (26,27) Complications of CPAP and BiPAP include nasal congestion, rhinorrhoea, epistaxis, facial skin erythema related to the mask, discomfort from air leak, abdominal distension, and midface retrusion. Regular long-term follow-up is necessary as pressure requirements will change and the interface will need to be upsized and adjusted with the growth and development of the child. (26,27)

- 6. Tracheostomy, Craniofacial Surgery:** craniofacial surgery has been shown to be successful in children with syndromic craniofacial abnormalities. Tracheostomy has the highest efficacy in the treatment of obstructive SDB when compared to other surgical interventions but is associated with worse quality of life and psychosocial development (41,42). Early onset complications include pneumo-mediastinum, pneumothorax, wound infection and bleeding, whilst late-onset complications include granulation tissue formation, tracheocutaneous fistulae, laryngo-tracheal stenosis, delayed language skills acquisition and increased rates of respiratory infections. In clinical practice, craniofacial surgery and tracheostomy are mostly reserved for the most severe cases when all other treatment options have failed. (41,42)

SUMMARY

In summary, there has been an considerable progress in the field of paediatric sleep medicine in the past few years. However, there still remain gaps in our knowledge particularly concerning the mechanistic pathways in the pathogenesis of paediatric OSA which inturn affects the protocol to be defined for a treatment plan. A better understanding of these will help in the development of novel treatment option which will benefit the pediatric population.

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