**Management of Obstructive Sleep Apnoea in Children: Past, Present and Future**

**Introduction**

 Obstructive sleep apnoea (OSA) is defined as episodes of partial or complete upper airway obstruction that disrupt the normal sleep architecture and normal ventilation patterns(1). This leads to sleep related symptoms such as snoring and laboured breathing. Aside from sleep related symptoms OSA can impact many other aspects of life, causing behavioural problems such as hyperactivity and inattention(2). More severe OSA can cause physiological sequelae including failure to thrive, reduced childhood development and cardiovascular complications. The prevalence of OSA is roughly 5% in children but this rises to closer to 50% in children with obesity(3). The causes of OSA are multifactorial but include, most commonly, adenotonsillar hypertrophy with congenital anatomical abnormalities and obesity also contributing(4). These varying causes of OSA can require different forms of management. In this essay I hope to give an overview of OSA in children through time to the modern day, and into the future.

**Past**

While there have been advances in the management of OSA over the last 50 years, a lot of the techniques used in the diagnosis and management would be familiar to those today especially with regards to the most common cause of OSA. Prior to the 1970’s enlarged tonsils and adenoids had largely only been studied in relation to inflammation and infection(5). Polysomnography and video fluoroscopy have been in use since the 1970’s(5). These investigations combined with clinical examination were, and still can be, helpful in determining a patient’s risk of developing OSA and if surgery is indicated. Polysomnography during the 1970’s included graphic recording of extraocular movements, electroencephalogram, electrocardiogram, oral and nasal thermistors, and an abdominal-strain gauge. The patients were also watched to observe any apnoeic episodes. One paper from 1980 describes that to improve the efficacy of sleep evaluation they planned to add cutaneous ear oximetry, this being a relatively new invention at the time, with pulse oximetry only becoming commercially available in 1974(5, 6). Some of the first documentation of using tonsillectomy and adenoidectomy for obstructive symptoms causing pulmonary hypertension, cor pulmonale and cardiac failure in children comes from 1965(7, 8).

**Present**

The treatment for paediatric OSA is dependant on the severity of symptoms, causal factors, and comorbidities. Treatment is generally indicated in moderate and severe OSA or in children with mild OSA with comorbidities(3). As the most common cause of OSA in children is adenotonsillar hypertrophy, it then makes sense that the most common surgical treatment is adenotonsillectomy. This cures airway obstruction in around 80% of cases(4). Although adenotonsillectomy is an affective treatment it is not without risks, including anaesthetic complications, poor oral intake, pain and bleeding or haemorrhage. Children with a higher risk of complications include children under 3 years old, or with obesity, comorbidities and severe OSA on polysomnography(9). Partial tonsillectomy or tonsillotomy is increasingly being used to treat OSA in children. Tonsillotomy involves removing tonsillar tissue but leaving the tonsillar capsule in place(10). This technique has lower complication rates compared to standard tonsillectomy but may be less effective in relieving symptoms in certain patients.

Several other surgical techniques are used in the management of OSA with indications depending on the individual patient’s airway findings, symptom severity and operative risks. Most of these other operations are not curative but may improve symptoms(4). Children with OSA and a narrow palate or crossbite have been shown to benefit from rapid maxillary expansion which aims to widen the palate to increase the airway size in pre-adolescent children(11). Patients with nasal congestion and enlarged turbinates have shown short term benefits from inferior turbinate reduction(12). In more complex cases of OSA including congenital syndromes, craniofacial abnormalities and neuromuscular disorders, the airway obstruction may occur at multiple levels. In these cases, imaging may be helpful to identify the level of the obstruction before targeted surgery which may involve techniques including UPPP (uvulopalotopharyngoplasty), tongue reduction, supraglottoplasty, lateral pharyngoplasty and mandibular distraction osteogenesis(4). Tracheostomy is a treatment reserved for use in children with severe OSA due to craniofacial abnormalities or neuromuscular conditions(3).

While surgery is the mainstay of management for OSA medical treatments are available. Continuous positive airway pressure (CPAP) therapy is the most used medical treatment. CPAP has been shown to be safe and effective for paediatric OSA patients(4). It is generally indicated in patients not suitable for surgery, obese patients, or those who have symptoms remaining after surgery. Although there are a range of oral and nasal masks available to fit paediatric patients, compliance is variable which can impact the efficacy of this treatment option(4, 13). Anti-inflammatory agents are another medical therapy option that may be effective in mild cases of OSA(14). Both intranasal corticosteroids and leukotriene receptor antagonists have been shown to improve symptoms of OSA individually but appear to be most effective when used together. While this treatment option was only tested on non-obese patients with mild OSA, combined intranasal steroids with oral montelukast did show a similar efficacy to adenotonsillectomy(15). This may be an effective treatment in this subgroup, limiting the number of children needing surgery. However, long term outcomes are unclear(4). With more research into their efficacy these could become a mainstay for treatment in children with mild OSA.

**Future**

Polysomnography is the current gold standard investigation for diagnosis of OSA. However, there is controversy around when this is indicated and how often it is used in clinical practice(3). Accredited sleep laboratories are rare and significant resources are required to perform polysomnography. Therefore, there is the need to develop alternative accessible screening and diagnostic methods. Multiple screening questionnaires are available, but their diagnostic accuracy is generally too low to be considered an alternative diagnostic method(16). An alternative diagnostic method involving a combination of symptom-based questions, examination findings and results from home sleep apnoea testing may work but this has not been tested(3). Current home sleep apnoea testing monitors fewer physiologic variables than full polysomnography but could have benefits over laboratory-based polysomnography, including reduced cost, resources, and disruption to family life(17). Home sleep apnoea testing has been used in uncomplicated adult patients but there is currently insufficient evidence to support its use in children(18). Advances in technology may help with improving validity of this method. Non-touch technologies using infrared light or radar non-contact sensors can now be used to detect heart rate and respiratory rate(19, 20). Advances in wearable technology that allow assessment of patient’s observations could also be incorporated into home sleep apnoea testing. Advances in artificial intelligence could be used to aid in the analysis of polysomnography data. These emerging technologies could aid the diagnosis of OSA making it cheaper and less intrusive.

For children who have persisting OSA after adenotonsillectomy the upper airway should be evaluated to locate the exact site of obstruction. This may be done using direct examination, flexible laryngoscopy, or radiographic imaging (lateral neck, airway fluoroscopy, or MRI). These traditional modalities all have the downside that the patient will usually be awake and therefore imaging may not be representative of the airway when asleep(3). Drug induced sleep endoscopy (DISE) is increasingly used to inform treatment. It uses sedation to simulate natural sleep and flexible laryngoscopy to evaluate the airways’ exact location of obstruction(4). DISE is more likely to identify functional obstruction and help those with complex airway problems(21). This can help to develop an individualized surgical plan on how best to improve a patients OSA. Larger studies should assess the outcomes associated with DISE directed surgical management and to identify patient populations that would benefit most from this investigation.

The prevalence of childhood obesity is on the rise and with it there is an increasing prevalence of OSA in children(22). How obesity contributes to OSA is likely multifactorial and not fully understood however obesity does increase the risk of OSA with some studies reporting a prevalence of up to 50% in obese children(23). This shift in epidemiology is likely to impact outcomes of current treatment. If adenotonsillar hypertrophy is present, then adenotonsillectomy is the first line treatment and does significantly improve OSA symptoms(24). However, persistent OSA is identified in 33-76% of obese children compared to 15-37% of non-obese children. This highlights obesity as one of the risk factors for persistent OSA following surgery, along with age greater than 7, severe disease and chronic asthma(25). A higher rate of persistent symptoms after adenotonsillectomy, linked to obesity, may lead to an increased requirement for second-line imaging and treatment. Residual OSA can be evaluated with DISE so its use may become more prevalent. Options for managing persistent OSA include airway investigation with potential surgical intervention, CPAP, and medical therapy(3). CPAP is a good treatment alternative in those with persistent symptoms but concerns about compliance remain(26). Secondary surgery is a potential management option but data on outcomes of these surgeries is sparse, with UPPP and supraglottoplasty post-adenotonsillectomy, so far demonstrating poor efficacy(27). Weight loss may improve OSA symptoms, though its affect is not well studied(4). In the future, weight loss may become more of a prevalent part of the management of OSA in children.

Implantable technologies such as upper airway stimulation systems may become more prominent in the treatment of OSA. These consist of an implantable pulse generator with a stimulation lead placed on the hypoglossal nerve and respiratory sensing electrode placed under the skin of the neck and chest(28). The remote activated device senses ventilation and activates the tongue protrusion function. Evidence for the use of hypoglossal nerve stimulation in children is sparse. It is unlikely that these devices will become as prominent as adenotonsillectomy but there may be cases where they are particularly useful. Studies on children with Down syndrome who had severe OSA and residual symptoms post-adenotonsillectomy showed improved symptoms and that the devices were well tolerated(29, 30). These studies were done on children with Down syndrome as this population have a higher incidence of OSA and posterior tongue collapse. These studies showed the device produced enough tongue movement to relieve obstruction and had a good level of compliance. With further research, these implantable devices may become a useful tool in the management of OSA in certain patients with resistant severe OSA.

Nasal expiratory positive airway pressure devices are an alternative potential treatment in those with symptoms after surgical treatment or are unable to tolerate CPAP(4). These devices are placed just inside the nostril and consist of a one-way valve which opens on inspiration and closes on expiration. During expiration the air is forced through small outlets, increasing airway pressure and helping to keep the airways open until the next inhalation. The safety and efficacy of these devices has not been established for use in children but there is limited evidence that they may improve symptoms in OSA(31). These devices are marketed as easy to use and travel friendly and so may have use in certain circumstances.

Orofacial myofunctional therapy consists of exercises to strengthen the muscles required for normal breathing by increasing the tone and mobility of both oral and cervical structures(32). While positive outcomes have been shown in adults, there is limited evidence for its use in children(33). This could become a non-invasive adjunct for the treatment of OSA.

**Conclusion**

OSA has a range of different causes and treatment options available. Although adenotonsillectomy is the mainstay of treatment and is likely to remain as such, there is ongoing research and new technologies which could advance the treatment of OSA, particularly in those cases that have been resistant to treatment with surgery or have other comorbidities such as obesity. Future treatment and management will have to look at how best to tackle these shifts in epidemiology while ensuring the efficacy and safety of future technologies for the management of OSA in children.

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