Obstructive Sleep Apnea in Children

Case Study and Commentary, *Craig Canapari, MD*

Abstract

- *Objective:* To review the evaluation, management, and pathophysiology of obstructive sleep apnea (OSA) in children.
- *Methods:* Literature review in the context of a clinical case.
- *Results:* The estimated prevalence of OSA in the pediatric population is approximately 2% to 4% and is becoming more common given the increasing prevalence of obesity. OSA is characterized by recurrent obstruction of the upper airway, resulting in sleep fragmentation and gas exchange abnormalities. The cause of OSA is increased upper airway resistance and collapsibility. The diagnostic modality of choice is polysomnography. Adenotonsillectomy is first-line treatment in children with adenotonsillar issues, although obese patients may have residual disease. If OSA is left untreated, neurobehavioral, cardiovascular, and metabolic complications can result.
- *Conclusion:* OSA is a common disorder in children and adolescents, especially in the context of obesity. Aggressive management is warranted to avoid significant sequelae.

Obstructive sleep apnea (OSA) is a common problem in children. OSA is characterized by a pattern of recurrent partial or complete upper airway obstruction with resultant sleep fragmentation and gas exchange abnormalities such as hypoxemia and hypercarbia [1]. The prevalence of parent-reported consistent snoring in children is 1.5% to 6%, while the prevalence of sleep-disordered breathing is between 4% and 11% based on parent questionnaires [2]. Historically, its prevalence has been estimated at 1% to 4% in lean children [2–4]. Approximately 16% of children are overweight (body mass index [BMI] > 95th percentile for age [5]), and this percentage continues to increase [6]. The increased prevalence of overweight in children has likely resulted in an increased prevalence of OSA, although not all trials have shown a positive relationship between obesity and OSA [2]. Approximately 36% of obese children will suffer from some degree of OSA, with more than 50% of snoring obese children affected [7–9]. Other risk factors include male gender and African-American race [2,10]. Some authors have proposed that there are 2 phenotypes of OSA: one comprised of younger children with adenotonsillar hypertrophy who are frequently hyperactive, and another comprised of obese children who are hypersomnolent [11]. The following case study is used to illustrate the nature of OSA in children, including pathophysiology, clinical sequelae, and treatment options.

CASE STUDY

Initial Presentation

A 14-year-old girl presents to her primary care physician with her parents, who are concerned about her snoring and difficulty getting out of bed in the morning.

History

The patient has a history of loud snoring for the past several years. At first, the patient's parents thought nothing of it, as everyone at home snores loudly. The patient occasionally experiences pauses in breathing during which she seems to be struggling to breathe, especially if she has an upper respiratory infection. She is a restless sleeper and tends to sweat a lot at night. She has no difficulty with falling asleep and usually does not awaken at night. She denies any history of sleep attacks, hypnagogic hallucinations, sleep paralysis, or cataplexy.

The patient's parents note that more recently she has had difficulty getting up in the morning, seemingly independent of when she goes to bed on the previous evening. The patient's usual bedtime is 10 PM, and she has to get up at 6:30 AM to catch the school bus. Her parents usually have to go into her room 4 or 5 times before she is able to get out of bed. Recently, she has started taking naps occasionally after school. On the weekends, she may go to bed as late as midnight and will sleep until 12 or 1 PM if she is not awakened.

She has been late to school 10 times this semester. Her grades have worsened since the previous year, having gone from As and Bs to Bs and Cs. Her teachers have noted on progress reports that frequently she appears to be daydreaming in class. The patient reports that she occasionally "nods off" in class. One of her teachers requested that the parents ask the primary care physician about attention-deficit/hyperactivity disorder (ADHD).

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Table 1. Polysomnographic Criteria for Obstructive Sleep Apnea (OSA) in Children

Diagnosis	AHI, events/hr		SpO_2 Nadir, %	Peak P_{ETCO_2}, mm Hg	P_{ETCO_2} > 50 mm Hg, % of Total Sleep Time
	Child	Adult*			
Mild OSA	1–5†	5–15	86–91	> 53	10–24
Moderate OSA	6–10	16–30	76–85	> 60	25–49
Severe OSA	> 10	> 30	≤ 75	> 65	≥ 50

AHI = apnea-hypopnea index; P_{ETCO_2} = partial pressure of end-tidal carbon dioxide; SpO_2 = arterial oxygen saturation as measured by pulse oximeter. (Adapted from reference 12.)

*Provided for comparison.

†The cutoff for OSA is defined as 1 obstructive sleep apnea per hour.

Her medical history is otherwise unremarkable. Review of systems is notable for persistent nasal congestion and mouth breathing as well as occasional heartburn. She has also had difficulties with weight gain for the past several years. Family history is notable for obesity in both parents and heart disease in her paternal grandfather. There is no family history of narcolepsy, restless leg syndrome, insomnia, or other sleep disorders. From a social standpoint, she generally enjoys school but has not been participating in any extracurricular activities as a freshman in high school because she is too tired after school. She denies any history of alcohol or elicit drug use, and her parents have no concerns about this issue.

Physical Examination and Laboratory Evaluation

The patient's height is 60 in and she weighs 148 lb. Her BMI is 28.9 kg/m^2, which is at the 96th percentile for her age. Her blood pressure is 121/90 mm Hg, which is notable for a mildly elevated diastolic pressure despite use of an appropriately sized cuff. The oropharyngeal examination demonstrates 2+ tonsils, a Mallampati III airway, 4 mm of overjet, and some mild maxillary constriction. Her nasal turbinates are mildly swollen. The neck examination is notable for mild acanthosis nigricans. The remainder of her physical examination is unremarkable.

Laboratory testing reveals the following: fasting lipid panel notable for a total cholesterol level of 141 mg/dL, a high-density lipoprotein cholesterol level of 24 mg/dL (low), a low-density lipoprotein cholesterol level of 85 mg/dL, and elevated triglycerides at 162 mg/dL; fasting blood glucose level of 86 mg/dL; and a fasting insulin level of 25 μIU/mL (elevated). These findings are consistent with the metabolic syndrome.

A polysomnogram is obtained. Her apnea-hypopnea index (AHI) is 21 events/hr, with a minimum oxygen saturation of 85%. Respiratory events consist of frequent obstructive hypopneas and occasional obstructive apneas, with a few central apneas during rapid eye movement (REM) sleep. These findings are consistent with severe OSA.

- **How is sleep-disordered breathing defined and classified in children?**

Sleep-disordered breathing is a common and serious problem in childhood, representing a spectrum of disorders from primary snoring to frank OSA [12]. The hallmark of these disorders is increased upper airway resistance. Habitual snoring is common in the pediatric population [3,4] and is generally present in all subtypes of sleep-disordered breathing.

OSA is characterized by the presence of obstructive apneas and hypopneas, which are defined as complete and partial cessation of airflow secondary to upper airway obstruction [1]. Apneas occur less frequently in children than adults but are more commonly accompanied by significant desaturations, likely due to decreased functional residual capacity [13,14]. The defining metric of OSA is the AHI, which includes all apneas and hypopneas averaged per hour of sleep (**Table 1**). The cutoff for normality is usually defined as 1 obstructive apnea per hour. However, this limit was defined based on the 97.5 percentile of an asymptomatic population and thus represents statistical but not necessarily clinical significance [15]. Other metrics, such as the frequency or severity of oxygen desaturation, may more accurately correlate with daytime symptoms or sequelae [16]. Moreover, there is controversy as to what degree, if any, of increased upper airway resistance is benign in children. Other phenotypes of increased upper airway resistance, including primary snoring, the upper airway resistance syndrome, and obstructive hypoventilation, are also found in children and may also be associated with sequelae [17]. Primary snoring is defined as the presence of snoring in the absence of disrupted sleep (defined as an increased arousal

index), respiratory events, or gas exchange abnormalities such as oxygen desaturations or hypercapnia. The upper airway resistance syndrome is comprised of disrupted sleep and frequent arousals without frank respiratory events and is associated with daytime symptoms such as inattention or sleepiness [18]. Obstructive hypoventilation does not meet standard AHI criteria for OSA but is characterized by persistent airflow limitation, hypercapnia, and low oxygen saturation [19].

- **What are the risk factors for OSA in children? What is the pathophysiology?**

Risk factors for OSA can be divided broadly into conditions that lead to narrowing of the upper airway (eg, deviated septum, enlarged turbinates, adenotonsillar hypertrophy, midfacial hypoplasia, retro- or micrognathia, macroglossia, chronic sinusitis) [10], conditions that reduce muscle tone (eg, neuromuscular disorders, Down syndrome) [20–25], and genetic factors (eg, craniofacial syndromes such as Pierre-Robin sequence and Treacher Collins syndrome [26–28], Down syndrome [20,21,29], a positive family history, African-American race [10]). Obesity drastically increases the risk for OSA by decreasing functional residual capacity via a mechanical effect on the chest wall andnarrowing the upper airway, a result of increased resistance caused byfat deposits [7–9,30,31]. Additionally, abdominal fat can impair ventilation, resulting in more severe gas exchange abnormalities [31–33].

The underlying cause of OSA is increased upper airway resistance. Children with OSA have narrower upper airways in terms of cross-sectional area compared with normal children [34,35]. Moreover, these airways are more compliant and thus prone to collapse [35]. Anatomic properties, however, only explain part of the pathophysiology of OSA. Obstructive events are less common in children than adults despite the fact that infants and children have a much smaller airway caliber. Patients with OSA breathe normally when awake and much of the time while asleep. This seems to be due to a vigorous neuromuscular response of the upper airway to negative pressure challenges, which is strongest in infants and children and decreases with age [36]. Among normal children, there is a wide variety of neuromuscular response to negative pressure [37]; thus, children with a less vigorous response of the upper airway dilator muscles may be vulnerable to OSA if they develop other conditions, such as obesity or adenotonsillar hypertrophy. Children with OSA have elevated upper airway dilator muscle tone compared with normal children, and the application of topical anesthetics to reduce upper airway muscle tone has demonstrated that the upper airway narrows markedly in children with OSA but not in unaffected children [38,39]. This suggests that children with OSA have more anatomically vulnerable airways, which are dependent on neuromuscular compensation to maintain patency. The effect of the anesthetic is analogous to the decrease of muscle tone that occurs during sleep, especially during REM sleep. Indeed, OSA is usually worse during REM sleep, when muscle tone is greatly reduced throughout the body [40]. Patients with defects of neuromuscular control, whether static (cerebral palsy) or progressive (Duchenne's muscular dystrophy), may have OSA due to dysfunctional neuromotor control in the upper airway [24,25].

Increased upper airway resistance and collapsibility causes frequent episodes of obstruction of the upper airway. Obstructive apnea is characterized by complete obstruction of the upper airway for at least 2 breaths in the presence of continued effort, whereas obstructive hypopneas are characterized by partial obstruction of the upper airway accompanied by either a 3% desaturation or cortical arousal [41]. The result is significant sleep fragmentation and gas exchange abnormalities, the combination of which give rise to the associated sequelae of OSA [42].

- **What are the sequelae of OSA in children?**

Neurobehavioral sequelae are well described in children with OSA. Like adults with OSA, older children and obese children tend to have excessive daytime sleepiness due to sleep fragmentation [43,44]. In younger children, behavioral symptoms such as hyperactivity, impulsivity, and aggression are common and can overlap with increased sleepiness [45–49]. OSA appears to cause cognitive impairment and decreased academic performance as well [16,50–52]. Although treatment with adenotonsillectomy seems to improve both behavior and cognition [47,51,53], there may be residual long-term deficits [54]. Some studies suggest that even primary snoring may not be benign. A recent study showed improvement in attention and hyperactivity in children who underwent adenotonsillectomy, regardless of whether or not they had OSA on polysomnography [53]. Children with primary snoring have been shown to have problems with attention and social issues compared with their peers as well as decreased performance in school years later [54,55]. Decreased quality of life is an often overlooked effect of OSA, with a a recent meta-analysis finding quality of life in children with OSA comparable to that of children with juvenile rheumatoid arthritis [56]. Treatment with adenotonsillectomy has been proven to improve quality of life on standard measures [56–60].

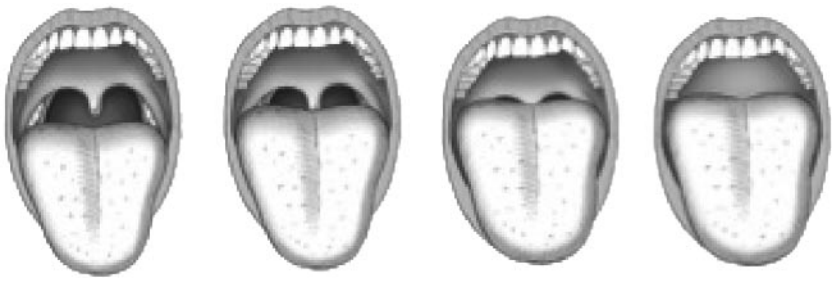

Figure 1. Mallampati airway classification. Class I = soft palate and entire uvula visible; Class II, soft palate and portion of the uvula visible; Class III = soft palate visible and may include base of the uvula; class IV = soft palate not visible. (Reprinted with permission from Nuckton TJ, Glidden DV, Browner WS, Claman DM. Physical examination: Mallampati score as an independent predictor of obstructive sleep apnea. Sleep 2006;29:903–8.)

Equally concerning are the cardiovascular and metabolic effects of OSA, which are becoming more prominent with the increasing incidence of obesity. Diastolic hypertension is clearly associated with OSA in children [61]. OSA is a proinflammatory condition, with significant local inflammation in the tissues of the upper airway in affected children [62,63]. Multiple measures of systemic inflammation, including C-reactive protein (a risk marker for atherosclerosis and future cardiovascular disease [64,65]) are elevated in children with OSA [66,67] and reduced after adenotonsillectomy [68], although one small study has disputed this relationship [69]. OSA also seems to induce insulin resistance in obese and nonobese children [66,70,71], although weight is likely the primary factor driving insulin resistance in morbidly obese children [72]. OSA increases the risk of the metabolic syndrome (the combination of obesity, hypertension, insulin resistance, and dyslipidemia [73]) in obese adolescents six fold [70]. Treatment with adenotonsillectomy reduces dyslipidemia in obese and lean children with OSA and increases insulin sensitivity in obese children with OSA [68].

- **What is the approach to diagnosis of a child with OSA?**

Evaluation of a child with suspected OSA begins with the history and physical examination. Historical signs and symptoms are divided into nocturnal and daytime manifestations of the disorder. Nocturnal symptoms reflect recurrent upper airway obstruction and are characterized by snoring, witnessed apneas, gasping and choking, and disrupted sleep. The majority of patients with OSA will snore. However, parent-reported snoring is predictive of snoring in the sleep laboratory but does not necessarily predict OSA [13]. Witnessed apneas are a fairly sensitive sign of OSA but often are not noted in older children sleeping in their own rooms. Moreover, REM sleep, when obstructive events are most common, tend to occur in the second half of the night, when parents are sleeping as well [74]. Older children may describe waking up choking and gasping. Restless sleep and frequent awakenings at night, especially in the context of snoring, are also suspicious for OSA. Enuresis may also occur with sleep fragmentation.

Daytime symptoms are variable in children. Adolescents may manifest the classic finding of excessive daytime sleepiness and may be quite difficult to arouse in the morning for school. Younger children (ie, preschoolers and children in elementary school) are more likely to have a paradoxical manifestation of disrupted sleep, with prominent hyperactivity, inattention, aggression, and impulsivity [49]. These symptoms can mimic ADHD; thus, attentional symptoms in the context of snoring and disrupted sleep merit further evaluation [75,76].

Physical examination findings are variable. A detailed examination of the upper airway is important to assess for causes of airway obstruction [77]. Mouth breathing and adenoidal facies (infraorbital darkening, elongated face, frequent mouth-breathing) are associated with OSA. Swelling of the nasal turbinates and a broad-based or deviated septum can contribute to increased upper airway resistance. Tonsillar hypertrophy is common in children with OSA. Originally designed to predict difficult airway management for anesthesiologists, the Mallampati classification is a useful tool in the evaluation of a child with suspected OSA [78]; Mallampati III and IV airways are predictive of OSA in older children (**Figure 1**) [79]. The dental examination is frequently overlooked. A high-arched palate, maxillary constriction, and retrognathia are consistent with a narrowed upper airway. Maxillary constriction is evidenced by a posterior cross bite (ie, maxillary molars are narrower than mandibular molars) [80]. Retrognathia is characterized by increased overjet (the distance between the upper and lower incisors) greater than 1 to 2 mm.

Polysomnography

The majority of children with suspected OSA are treated

empirically with adenotonsillectomy or medical therapy such as nasal steroids to reduce upper airway resistance. If the case is complicated or does not respond to treatment, a polysomnogram may be obtained. Pediatric polysomnography remains the gold standard for diagnosis of OSA [1,29,81]. It allows differentiation of primary snoring from OSA and determination of disease severity, and may help clarify the diagnosis in children with disrupted sleep. It also may detect other processes fragmenting sleep such as nocturnal seizures or periodic limb movements of sleep. No other test can conclusively rule out OSA in children [82]. Polysomnography is performed overnight with a technician present and records multiple parameters. Measures of sleep stage and sleep disruption include electroencephalogram, electrooculogram, and electromyogram tracings. Respiratory parameters include nasal pressure, oronasal flow, snore microphone, end tidal CO_2, and effort bands around the thorax and abdomen. Other channels such as the electrocardiogram and video are also recorded [81]. Other modalities, such as home polysomnograms [83,84] and videotaping [85], may detect some cases of OSA but lack specificity and sensitivity. Intermittent oxygen desaturations, as detected by a home recording oximeter, are highly suggestive of OSA. However, this modality is fairly insensitive [86].

• How is pediatric OSA treated?

Treatment is indicated for patients with moderate to severe OSA. Patients with mild disease who are symptomatic may also benefit from treatment. Patients with mild disease may have a significant benefit from nasal steroid and/or montelukast treatment, which probably works by shrinking swollen nasal tissue [63]. Adenotonsillectomy is first-line therapy for most children with significant adenotonsillar hypertrophy [29], and is effective even in obese children [87]. The American Academy of Pediatrics recommends overnight observation for children with severe obesity, severe OSA, and various other risk factors (**Table 2**), given a high risk of postoperative respiratory problems [81,88–90]. There is also evidence to suggest that children with OSA are more sensitive to opiates and thus require very careful titration of postoperative pain medication to avoid respiratory complications [91–93].

Adenotonsillectomy has been shown to be effective treatment, even in obese children [87,89]. However, a significant subset of children will have residual disease [94]. Ninety-four of 199 children in a prospective study followed post-adenotonsillectomy had some degree of residual OSA [79]. The risk factors for residual disease included Mallampati III or IV airways, swollen nasal turbinates, and a deviated septum. For this reason, it is important to address other causes of increased upper airway resistance, such as septal deviation or enlarged inferior turbinates, at the time of surgery if indicated. Obese children initially have a good response but are likely to have recurrent disease if they continue to have an elevated BMI or have a rapid increase in BMI postsurgery [95]. Thus, patients with severe OSA are likely to have residual or recurrent disease. The American Academy of Pediatrics recommends repeat polysomnography and further treatment if indicated for such patients [89].

Table 2. Risk Factors for Postoperative Respiratory Complications in Patients with Obstructive Sleep Apnea (OSA) Undergoing Adenotonsillectomy

Age < 3 yr
Severe OSA on polysomnography
Cardiac complications of OSA (eg, right ventricular hypertrophy)
Failure to thrive
Obesity
Prematurity
Craniofacial abnormalities
Recent respiratory infection
Neuromuscular disorders

Adapted from reference 89.

For patients who have significant residual disease after treatment or who are poor candidates for surgery, continuous positive airway pressure (CPAP) therapy may be effective, even in very young children or children with craniofacial disease [96–98]. CPAP therapy involves application of positive pressure via a nasal or oronasal mask. Usually, the pressure is titrated in the sleep laboratory to determine the optimal pressure. Compliance is frequently an issue, as CPAP is a long-term treatment and not a cure [99–101]. CPAP treatment is more likely to be successful if behavioral modalities such as habituation are used [101,102].

A promising modality is rapid maxillary expansion, an orthodontic technique that opens the sagittal suture of the hard palate and can result in significant improvement of OSA in selected cases, specifically patients with maxillary crowding and residual disease after adenotonsillectomy (**Figure 2**) [80,103]. Patients with residual OSA after adenotonsillectomy may have lingual tonsillar enlargement as well and will respond to resection [104,105].

Follow-up to Clinical Case

The patient is referred to an otolaryngologist for evaluation of her upper airway. She has an adenotonsillectomy and turbinectomy and is observed overnight in the hospital. Six weeks later, she undergoes a repeat polysomnogram, which shows mild to moderate residual OSA

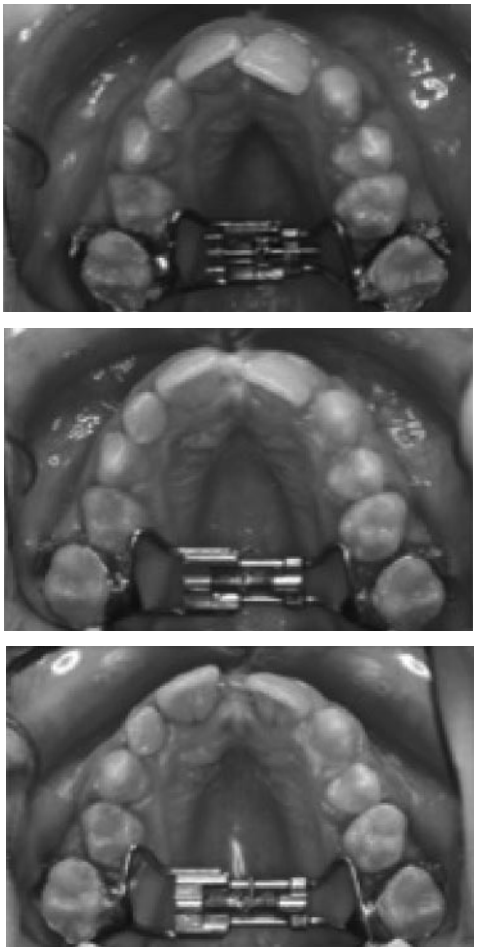

Figure 2. Treatment with rapid maxillary expander. (Reprinted with permission from reference 80.)

(AHI of 5.5 events/hr with a minimum oxygen saturation of 90%). Despite the residual disease, the patient and her parents both note that her energy and concentration during the day have improved. She is also referred to an obesity clinic for evaluation and management of her weight issues as well treatment of her dyslipidemia. Her primary care physician explains that the residual OSA may worsen and require further treatment if she continues to gain weight.

SUMMARY

The increasing incidence in obesity has resulted in an increased prevalence of OSA. OSA is a cause of significant neurobehavioral, cardiovascular, and metabolic sequelae and represents an important and treatable risk factor for the metabolic syndrome. Obese children represent a therapeutic challenge, as adenotonsillectomy may only result in incomplete improvement. Ongoing evaluation and management of OSA must be coupled with aggressive weight management measuresin obese children.

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