Literature Review

Sleep Disordered Breathing in Infants and Children: A Review of the Literature

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Abstract: *The objective of this report was to review the etiology, diagnosis, and treatment of sleep disordered breathing (SDB) in children and infants. English peer-reviewed SDB literature identified by MEDLINE and a manual search conducted between 1999 and 2006 was selected. The keywords used for the search included: (1) children; (2) sleep disorder; (3) snoring; and (4) obstructive sleep apnea. A total of 153 manuscripts was identified. A delay in treatment of SDB children may be caused by several factors and may result in serious but generally reversible problems, including: (1) impaired growth; (2) neurocognitive and behavioral dysfunction; and (3) cardiorespiratory failure. Adenotonsillectomy is the treatment of choice, and continuous positive airway pressure may be an option for patients who are not candidates for surgery or who do not respond to surgery. Minimal information is available concerning the dental treatment of these disorders. With the devastating effects sleep disorders can have on children and their families, dentists must recognize obvious symptoms and refer these patients for management by physicians. (Pediatr Dent 2007;29:193-200)*

KEYWORDS: SLEEP DISORDERED BREATHING, OBSTRUCTIVE SLEEP APNEA, ADENOTONSILLECTOMY, BEHAVIORAL PROBLEMS, DOLICO FACIAL PATTERN

In 1966, Gastaut et al first used polysomnography to study patients exhibiting daytime sleepiness, hypoventilation, and upper airway obstructions. They determined that these events were associated with sleep disorders and apnea periods.[1] Sleep disordered breathing (SDB) in adults is a potentially life threatening condition that has been well documented in the medical literature. Dentists have become actively involved with managing SDB patients with oral devices.

When observed in infants and children, these same conditions are rarely recognized by dentists. While the symptoms may be different from those seen in adults, the condition is no less severe and, in fact, may have far reaching consequences not seen in adults. It is, therefore, imperative that dentists recognize potential SDB in infants and children and refer these patients to medical colleagues for proper diagnosis and treatment. The early SDB literature focused on these conditions in adults. Reports of SDB in children in the literature have increased, however, as evidenced by the 153 publications identified in the medical/dental literature in the past 6 years.

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The purpose of this article was to scrutinize peer-reviewed sleep disordered breathing literature identified by Medline and by manual search of pertinent articles conducted between 1999 and 2006. The keywords used for the literature search were: (1) children; (2) sleep disorder; (3) snoring; and (4) obstructive sleep apnea. The adult literature is briefly reviewed to provide necessary background information. The significance of the disease process, diagnosis, and treatment of SDB children and infants is discussed.

Sleep disordered breathing

When discussing SDB, 2 conditions must be defined:

1. apnea, a cessation of airflow (breathing) lasting for at least 10 seconds[2];
2. hypopnea, a 50% reduction in airflow for 10 seconds or more, usually associated with blood oxygen (SaO2) desaturation.[2]

Anatomy and physiology

Obstructive sleep apnea (OSA) and upper airway resistance syndrome (UARS), as implied, are physiologically related to the upper airway. Anatomical components of the upper airway are the: (1) oral cavity; (2) hypopharynx; (3) oropharynx; and (4) nasopharynx. In nonsleep disorder patients, as the diaphragm attempts to pull air through the upper airway during inspiration, a negative pressure is created due to airflow resistance caused by the airway walls.[3] As the pressure re-

duction occurs, there is a resulting decrease in the airway's shape, which is normally retained by activity of the tensor veli palatine and genioglossus muscles. For SDB patients, the upper airway is often completely compromised—resulting in a reduction of oxygen reaching the lungs and vascular system. This compromise may be due to any condition that causes impingement on the airway. An incomplete blockage may cause the oral soft tissues such as the uvula to vibrate, resulting in the sound of snoring. Complete obstruction results in OSA.

The available airway space may also be reduced by abnormalities of the: (1) oral cavity; (2) larynx; (3) nose; (4) nasopharynx; or (5) oropharynx. These abnormalities may include: (1) structural changes to the upper airway; (2) obesity; (3) adenotonsillar hypertrophy; (4) polyps; (5) edema of the epiglottis; or (6) tumors.[4-6] Assuming the supine position when any of these conditions are present may cause a blockage of the airway space. Two studies[7,8] indicate that SDB patients may, in an attempt to maintain a patent upper airway, subconsciously exhibit: (1) a more extended neck; (2) anterosuperior movement of the hyoid bone; (3) upward and forward movement of the mandible; and (4) a more upright tongue position.

Children and infants

Although not well recognized by dentists or physicians,[9-11] sleep disorders among children and infants and how they affect these young patients is well documented in the medical literature. SDB is common in children. Part of the problem, however, may be that many of the clinical features of children with these sleep disorders differ markedly from those seen in adults.[12] Approximately 3% to 12% of children snore, and 1% to 10% of these patients may have OSA.[13] Caprioglio et al[14] found that the onset of snoring may begin as early as 22.7 months and apnea at 34.7 months. Other authors[10] have reported similar results. Ersu et al[15] found that 7% of children studied were habitual snorers and, compared to nonsnorers, exhibited a higher prevalence of: (1) difficulty in breathing; (2) observed apneas; (3) restless sleep; (4) parasomnias; and (5) nocturnal enuresis. These subjects also were more likely to fall asleep while watching television and in public places and were hyperactive. The authors also found that the presence of asthma and hay fever increased the likelihood of habitual snoring along with exposure to cigarette smoking at home. Another study[16] indicated a familial basis for OSA. Because sleep disorders among children and infants are well described and may have devastating affects on families, it is important that dentists are able to recognize these disorders.

Significance of disease process

Sleep disorders may be manifested by multiple symptoms in young children and infants and may cause severe medical, behavioral, and and/or sociological problems. Concerning behavioral and sociological components of these airway disorders, one study[17] demonstrated that almost 25% of OSAS children had clinically significant behavioral sleep problems such as sleep walking and nightmares as well as a greater incidence of daytime externalizing behavior problems. In a more recent study, Rosen et al[18] found a higher prevalence of problem behaviors and hyperactive-type behaviors in children with relatively mild SDB. In addition to these findings, almost 26% of children with mild symptoms of attention-deficit/hyperactivity disorder (ADHD) also demonstrate OSA, as observed during polysomnography testing.[19] More recently, in a study of ADHD children 6 to 14 years old, Sangal et al[20] found neither OSA nor Periodic limb movement disorder (PLMD) to be a common underlying disorder or etiologic factor in patients who met the criteria for ADHD.

Becker et al[21] suggest that neurobehavioral problems in children with epilepsy may be attributed, in part, to an underlying sleep problem. In a study of 5-year-old children, Gottlieb et al[22] found SDB symptoms to be associated with poorer executive function and memory skills and lower general intelligence. In a study of preterm children, Emancipator et al[23] found that SDB children exhibited deficits in: (1) academic abilities; (2) language comprehension; and (3) planning and organizational skills.

Further evidence suggests a significant link between airway problems and emotional/behavioral conditions. For example, compared to those students registering more normal sleep duration,[24] children 11 to14 years old who were diagnosed as being sleep deficient exhibited: (1) lowered levels of self-esteem; (2) significantly lower grades; and (3) higher levels of depressive symptoms. Similarly, O'Brien et al[25] found significant differences in children with high or low sleep pressure scores (SPS). Compared to those children in the low SPS group, those in the high SPS group were more likely to have deficits in: (1) memory; (2) language abilities; (3) verbal abilities; and (4) some visuospatial functions. Regarding drug use as either an initiator or result of behavioral problems, Wong et al[26] demonstrated that the early onset of alcohol, marijuana, or illicit drug use by adolescents, as well as an early onset of cigarette use by the age of 12 to 14, could be significantly predicted by the mother's ratings of their children's sleep problems at ages 3 to 5 years.

Persistent sleep disturbance is likely to adversely affect: (1) cognition; (2) mood; (3) behavior; and (4) family function.[27] Gozad and Pope[28] found that children with lower academic performance in middle school were more likely to have snored in early childhood and have required a tonsillectomy and adenoidectomy. Perhaps more importantly, the authors speculated that SDB associated with neurocognitive

morbidity may not be completely reversible and may affect future school performance.

Urschitz et al[29] demonstrated that habitual snoring was significantly associated with lower academic performances in mathematics, science, and spelling in third grade children.

Sivan et al[30] found that infantile OSA does occur in infants due to hypertrophic adenoids and tonsils and that these infants failed to gain weight. Andreou et al[31] found that children with sleep disorders and ADHD disorder had a verbal intelligence quotient (IQ) up to 20 points lower than control subjects.

Another study's results[32] indicated that children with adenotonsillary disease and OSA had a higher prevalence of right and/or left ventricular enlargement. Ng et al[33] indicated that there is increasing evidence that childhood SDB/OSA is associated with detectable cardiovascular abnormalities. Suresh et al[34] found that 64% of patients 1 to 15 years of age with Duchenne muscular dystrophy reported sleep-related symptomatology.

Kennedy et al[35] stated that mild changes in oxygen saturation or increases in respiratory arousals may have a greater effect on neurocognitive function than previously reported. Unfortunately, although sleep problems are common in children with intellectual disability, many parents may not: (1) recognize the problem; (2) believe treatment is possible; or (3) seek treatment.[36] Bandla and Splaingard[37] stated that, given the adverse neurocognitive and physiologic outcomes associated with a deranged night's sleep, it is important for pediatricians to be able to anticipate, recognize, and appropriately manage these problems. To summarize, it has been demonstrated that emotionally governed behavior in children may be closely linked to previously diagnosed physiological problems such as OSA and airway obstruction.

Recognition

The recognition of a potential sleep disorder in children and infants may be based on: (1) facial morphology; (2) observation of behavioral problems; and (3) parental comments and observations. Of all observations made by parents, that of "snoring every night" is the most significant factor in predicting OSA.[38] Blunden et al,[39] however, found parents to dramatically under-report snoring. The authors showed that snoring was only mentioned by parents in 8% to 15% of children that snored.[39] Preutthipan et al[40] found that no single or multiple observations made by parents could accurately predict the severity of OSA.

Stein et al[41] found that boys were more likely than girls to have higher scores of nocturnal enuresis, with both groups having a significant increase in history of trauma associated with OSA and airway problems. Furthermore, the authors also reported that children who rated high on tiredness evaluations were more likely to have a history of hospitalizations than those not reporting OSA/airway obstruction.

Kikuchi et al[42] found that SDB children had the dolico facial pattern (a disproportionately long face). Migraine headaches may also be indicative of sleep disturbances.[43]

Finkelstein et al[44] reported that significant craniofacial abnormalities were seen in OSA patients and included:

1. increased flexure of the cranial base and bony naso pharynx;
2. opening of the gonial angle;
3. shortened mandibular length;
4. dorsocaudal location of the hyoid;
5. reduced posterior airway space; and
6. increased velar thickness.

Adenoidectomy generally is an effective treatment in children with obstructive sleep-related disorders. The authors speculated, however, that the underlying craniofacial problems may remain following adenoidectomy and may predispose the patient to redevelopment of obstructive breathing disorders in adulthood. Harding[45] stated that risk factors for sleep apnea in children include: (1) obesity; (2) being African American; (3) sinus problems; and (4) persistent wheezing. He also stated that, while Caucasians tend towards a brachycephalic facial type (a reduced anterior-posterior cranial dimension), African Americans tend towards leptoprosopic facial types (longer facial height and decreased facial width).

In reviewing suspected etiologies of SDB in children and adults, several physical characteristics of craniofacial structures have been radiographically evaluated as being either primary or secondary causal covariants. Cephalometric radiographic analysis is considered to be the gold standard for mapping and measuring craniofacial characteristics in the diagnosis and treatment of orthodontic problems.[46] Coupled with this analysis is the diagnostic classification of facial type and dental/soft tissue/skeletal relationships as they exist in children and adults. Facial type classification includes Angle's Class I, II, and III classifications and related subdivisions. Permutations of malocclusion and skeletal/soft tissue variations generally accompany these 3 main facial types.

Most studies incorporating these parameters have been interested in identifying certain cephalometric or facial landmarks as physical indicators for possible sleep disorders. For example, both obese and nonobese populations with diagnosed obstructive sleep disorders were evaluated using standardized cephalometric analysis. Reported findings in one study[47] suggest that nonobese patients with severe sleep disorders could be distinguished from other nonobese and obese groups on the basis of facial characteristics. In other words, patients characterized as being nonobese and having severe obstructive sleep apnea (OSA) may present with a greater facial vertical skeletal disharmony when compared to similar and dissimilar groups (obese vs nonobese and mild

vs severe OSA). Zucconi et al[48] demonstrated that cephalometric analysis of 26 children revealed:

1. a significant increase in craniomandibular intermaxillary;
2. lower and upper gonic angles with a retroposition and posterior rotation of the mandible (high angle face); and
3. a reduction in the rhinopharynx space.

Crossbites and labial incompetence as well as daytime symptoms were also seen. OSA patients in a separate study were found to have significantly different facial characteristics than control subjects (non-OSA); that is, OSA patients had a greater vertical facial height and greater mandibular plane measurements than non-OSA controls when cephalometrically evaluated using Ricketts analysis. When these data were analyzed using the Downs-Northwestern analysis, however, there was no significant difference between the OSA patients and controls.[49] While trends in cephalometrically measured parameters have been reported, there is limited corroborating longitudinal evidence to suggest that craniofacial skeletal and/or soft tissue tendencies identified in preadolescents and adolescents can be used as standards for predicting adult respiratory disorders.[50] Some authors[51] do conclude that existing soft tissue or skeletal structures can be suggestive of either current or future respiratory problems when cephalometrically analyzed. Caution is advised in reviewing these findings, however, since some conclusions may be drawn without the benefit of comparison control groups.

In conclusion, it must be noted that many OSA-related articles evaluating causation deal with adult patients. Any assumptions made regarding trends in development of OSA from childhood to adulthood must be cautious in nature due to, among other variables, the dominant and over-riding factor of growth as well as the lack of appropriate control groups. There are some facial characteristics, such as lower hyoid position, maxillomandibular micrognathia or retrognathia, and an increase in vertical facial developments, which may be more predictive when observed through longitudinal studies. Further caution is advised in making diagnostic and causative predictions based upon craniofacial differences, since these may lack statistical validity, sensitivity, and specificity.

Diagnosis

Because potential sleep disorders in children and infants are often unrecognized and under-reported, the diagnosis of these disorders is hindered.[9,10,52] In recognizing and managing young patients with OSA, physicians should follow the clinical practice guidelines as established by the American Academy of Pediatrics (AAP). Dentists should also be aware of the guidelines.[53] These guidelines recommend that, for the diagnosis of OSA:

1. All children should be screened for snoring.
2. Complex, high-risk patients should be referred to a specialist.
3. Patients with cardiorespiratory failure cannot await elective evaluation.
4. Diagnostic evaluation is useful in discriminating between primary snoring and OSA, with the gold standard being polysomnography.
5. Adenotonsillectomy remains the initial treatment for most children, and continuous positive airway pressure is an option for those who are not candidates for surgery or who do not respond to surgery.
6. High-risk patients should be monitored as inpatients postoperatively.
7. Patients should be re-evaluated postoperatively to determine whether additional treatment is required.

The use of polysomnography in children has been studied. Pang and Balakrishnan[54] questioned the routine need for a mandatory overnight polysomnography prior an adenotonsillectomy. Objective testing with polysomnography prior to adenotonsillectomy, however, has been recommend by for SDB children by the AAP.[55] Katz et al[56] found little clinical significance in night-to-night variability in pediatric polysomnography and no first-night effect. Caution must be used when diagnosing children with symptoms suggestive of OSA, since another study[57] found that half or fewer of these children actually had the condition when examined with polysomnography.

Treatment

Gozal and O'Brien[58] reported that OSA children have marked increases in health care-related costs. If prompt diagnosis and management are not implemented, some of these complications may not be completely reversible, resulting in long-lasting consequences. Adenotonsillectomy is the treatment of choice for most children, and continuous positive airway pressure may be an option for those patients who are not a candidate for surgery or who do not respond to surgery.[53,59] Uvulopalatopharyngoplasty, tracheotomy, and other surgical procedures are less frequently indicated. The results of a study by Nandapalan[60] indicate that children with cardiac pathology had reduced—but not eliminated—apneic episodes following adenotonsillectomy. Due to respiratory complications following adenotonsillectomy in children younger than 3, Statham et al[61] recommend hospital admission. In other studies,[62-65] caregivers detected a long-term improvement in quality of life following adenotonsillectomy for OSA, although the results were not uniform. Two studies[66,67] comparing tonsillectomy to tonsillotomy for treating OSA found that both procedures were equally effective, but that tonsillotomy was less traumatic and patients recovered more quickly. Richards and Ferdman10 found that 352 children and infants previous-

ly diagnosed with OSA—and eventually treated with tonsillectomy and/or adenoidectomy—exhibited common symptoms, including: (1) chronic mouth breathing (84%); (2) otitis media (64%); (3) sinusitis (56%); (4) sore throat (51%); (5) choking (47%); and (6) daytime drowsiness (42%). Less observed symptoms included: (1) poor school performance; (2) enuresis; (3) poor appetite and/or weight gain; (4) dysphagia; and (5) vomiting. Nieminen et al[68] found that growth hormone secretion, impaired in children with OSA and primary snoring, was corrected with adenotonsillectomy—resulting in weight gain and a restoration of normal growth.

Mansfield et al[69] reported that decreasing nasal congestion associated with allergic rhinitis can improve sleep in these patients and lead to improved daytime quality of life. A similar study[70] found that most patients showed improvement in nasal and sleep symptoms after correction of nasal airway obstructions. Nasal surgery alone, however, did not consistently improve OSA when measured objectively. Another study[71] found an improvement in both the polysomnography and symptoms of children with mild SDB within 4 weeks of using a nasal corticosteroid.

Downey et al[72] showed that continuous positive airway pressure (CPAP) can be effectively used in children younger than 2. Palombini et al[73] found that, in children 8 months to 12 years old, auto-CPAP was safe and effective in an attended environment. Auto-CPAP, however, did not eliminate all abnormal respiratory events. Topol and Brooks[75] found that children with snoring not related to a sleep disorder were not likely to develop polysomnography-confirmed OSA and, therefore, delayed treatment was safe.

The safe use of oral devices to treat SDB in adult patients is well documented.[76] The use of these types of devices in children, however, is not. Cozza et al[76] found that a modified monobloc device may be useful in children with mild to moderate OSA. The authors suggest further long term studies prior to wide use of these devices, however, because of concerns with the effects on growth patterns and compliance issues. Guilleminault et al[77] stated that, for patients with residual problems following adenotonsillectomy, collaboration with orthodontists to improve craniofacial risk factors should be considered. In a limited study of children with OSA, Lin et al[78] found that most who underwent mandibular distraction for upper airway obstruction associated with mandibular hypoplasia showed significant clinical improvement. Rachmiel et al also found[79] that, in 12 patients 12 months to 7 years old, mandibular distraction osteogenesis:

1. provided an increase in both mandibular and upper airway volume; and
2. reduced or eliminated OSA symptoms; and
3. prevented the need for tracheostomy.

Pirelli et al[80] found in a study of 42 children with a case history of oral breathing, snoring, and night-time apneas that rapid maxillary expansion brought a significant improvement to their condition. Therefore, an orthodontist may play an important role in the interdisciplinary treatment of OSA patients.

Conclusions

Rosen[81] summed up the diagnosis and management of children with obstructive sleep apnea hypopnea syndrome when he stated that failure to diagnose and treat these patients can result in serious but generally reversible problems, which may include: (1) impaired growth; (2) neurocognitive and behavioral dysfunction; and (3) cardiorespiratory failure. Furthermore, identifying these patients may be difficult, because they may not exhibit signs or symptoms while awake. Rosen recommends developing new diagnostic strategies that will help screen, identify, and treat these patients. With the information available and the devastating effects sleep disorders can have on children and infants and their families, dentists must be aware of the signs and symptoms or refer these patients for proper diagnosis and management physicians.

Although clear medical guidelines for the recognition and management of children with sleep disordered breathing exist, the role of dentists in managing such patients is not clear. At this time, however, dentists should be familiar with the signs and symptoms of these disorders in children and refer them to the appropriate medical colleagues for management. It is imperative that all infant and children patients receive at least cursory examinations for the potential existence of these disease processes.

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