It Is Just Attention-Deficit Hyperactivity Disorder…or Is It?

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CASE: **Carly is a 5-year-old girl who presents for an interdisciplinary evaluation due to behaviors at school and home suggestive of attention-deficit hyperactivity disorder (ADHD). Parent report of preschool teacher concerns was consistent with ADHD. Psychological testing showed verbal, visual-spatial, and fluid reasoning IQ scores in the average range; processing speed and working memory were below average. Carly's behavior improved when her mother left the room, and she was attentive during testing with a psychologist. Tests of executive function (EF) skills showed mixed results. Working memory was in the borderline range, although scores for response inhibition and verbal fluency were average. Parent ratings of ADHD symptoms and EF difficulties were elevated.**

Carly's parents recently separated; she now lives with her mother and sees her father on weekends. Multiple caregivers with inconsistent approaches to discipline assist with child care while her mother works at night as a medical assistant. Family history is positive for ADHD and learning problems in her father. Medical history is unremarkable. Review of systems is significant for nightly mouth breathing and snoring, but no night waking, bruxism, or daytime sleepiness. She has enlarged tonsils and a high-arched palate on physical examination.

At a follow-up visit, parent rating scales are consistent with ADHD-combined type; teacher rating scales support ADHD hyperactive-impulsive type. Snoring has persisted. A sleep study indicated obstructive sleep apnea. After adenotonsillectomy, Carly had significant improvement in ADHD symptoms. She developed recurrence of behavior problems 1 year after the surgery.

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The first publication of the association of sleep-disordered breathing (SDB) and symptoms of hyperactivity and inattention in children with snoring in 1982 launched research into this finding.[1] Subsequent reports confirmed that sleep disorders and, in particular, SDB were associated with a clinical presentation of attention-deficit hyperactivity disorder (ADHD).[2] Prepubertal children with disturbed nocturnal sleep, instead of presenting with daytime sleepiness, manifest their daytime impairment with hyperactivity. Snoring may be related to obstructive sleep apnea (OSA) or upper-airway resistance syndrome, but hyperactivity and inattention are present in both cases. Huang et al.[3] reported on an unselected group of 6- to 12-year-old children (N = 120) seen in an ADHD clinic. The authors found that many of the children had mild OSA. A group of children with mild OSA (n = 66) were prospectively divided into 3 groups: wait and see, methylphenidate, or adenotonsillectomy (T&A). Groups were compared with a diagnostic interview for ADHD, broadband and ADHD-specific parent and teacher behavior rating scales, and a continuous performance test. Both treatment groups improved, but the T&A group had more improvement than the medication group and did not need medication after T&A treatment.

Subsequent research has shown that T&A may not induce a permanent treatment of SDB[4] as the initial problem may be related to abnormal oral-facial growth, particularly during early infancy, which is not addressed by the T&A. The initial cause of abnormal oral-facial growth is often induced by an unrecognized abnormal lingual frenulum at birth.[5] The lingual frenulum is a vestigial embryological element that is mostly fibrous in its consistency. It may not undergo proper apoptosis during embryogenesis, limits movements of the tongue, and is commonly known as "tongue-tie." It should be observed and addressed during a physical examination. Re-education of normal nasal breathing through myofunctional therapy is also needed for long-term successful treatment of SDB. Myofunctional reeducation involves strengthening of the tongue and orofacial muscles by teaching individuals how to reposition muscles to the appropriate position and teaching to continuously breathe through the nose. This treatment also maintains improvement of clinical symptoms, including inattention, more important than hyperactivity, in older

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children.[6] In summary, factors inducing SDB and all causes of abnormal breathing during sleep should be systematically investigated in Carly and all children with ADHD.

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Obstructive sleep apnea (OSA) is common in children with around 1% having a persistent problem, mostly from enlarged tonsils and adenoids. Because children are exposed to multiple antigens passing through the aerodigestive tract, lymphocytes in Waldeyer ring are stimulated, resulting in enlargement of the adenoids, palatine tonsils, and lingual tonsils. Proliferation of lymphoid tissues can be exuberant with subsequent obstruction; the trajectory of growth can also be highly variable. Adenoidal hypertrophy peaks at age 3 years, but enlargement can persist into adolescence. Children develop nasal congestion with frequent ear and sinus infections. They maintain an open mouth posture, which can result in dentofacial abnormalities. The classic "adenoid facies" was recognized over a 100 years ago. Children also begin to exhibit symptoms of OSA: snoring, gasping, and breathing pauses while sleeping restlessly, sweating, bed wetting, waking irritably with moody mornings, and episodes of excessive daytime sleepiness. Enlarged tonsils peak at around 6 years of age and cause the same symptoms, but hyperactivity, inattentiveness, and daytime tiredness become more prominent as children begin school. Hyperactivity and inattentiveness, without other symptoms of OSA, are rarely the result of lymphoid hypertrophy.[1]

Diagnosis is based on the child's history, physical examination, and a polysomnogram (PSG). Examination includes assessment of the nose, emphasizing the septum and turbinates; oral examination focuses on shape of the dental arch, tongue size and position in relation to the palate, and size and shape of the tonsils. A fiberoptic nasal endoscopy can confirm adenoid enlargement, and a deeper laryngoscopy will show the inferior extent of the tonsils and size of the lingual tonsils. We obtain a PSG on all children younger than 3 years; in children with obesity, Down syndrome, attention-deficit hyperactivity disorder, and autism; and in children with symptoms of OSA and no obvious site of obstruction. Healthy children older than 3 years with symptoms and examination consistent with OSA generally do not require a PSG before recommending intervention.

Sleep-disordered breathing in children from enlarged tonsils and adenoids has been recognized since the 19th century, and its treatment with adenotonsillectomy (T&A) has been advocated for nearly as long. The majority of the half million tonsillectomies performed in the United States annually are performed for OSA. Since the advent of PSGs, the use of T&A as an effective treatment has been confirmed. Cure rates range from 50% to 80%, depending on comorbidities. The problem with tonsillectomy is the 5- to 10-day recovery, considerable pain, and an irreducible rate of postoperative hemorrhage of 1% to 2%. An alternative is an intracapsular "partial" tonsillectomy, which has a shorter recovery with less pain, virtually no postoperative bleeding and equal effectiveness in appropriately selected children. The drawback to the partial procedure is a higher rate of tonsillar regrowth of 1% to 2%. Given the significant failure rate of T&A to relieve OSA in some children, the idea of a "larger" tonsillectomy by enlarging the oropharyngeal inlet through an expansion pharyngoplasty is now possible. The alternative to surgery is continuous positive airway pressure which is highly effective, but difficult to achieve good compliance without intense parental involvement.[2–4]

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Mouth breathing (MB) is an abnormal mode of respiration. The function of the nose to filter, warm, and humidify the air is bypassed, as inspiration of a drier, unfiltered air, occurs.[1] Normal respiration is a combination of oral and nasal breathing. The distinction between both states is difficult to detect and to measure. Clinical examination, respiratory tests, medical history, and MB quality-of-life questionnaires are used; however, this clinical strategy to define MB has not been universally validated.

Mouth breathing can be the consequence of increased nasal resistance that results from nasal obstruction from allergic rhinitis and/or adenotonsillar hyperplasia.[2]

However, MB can be a habitual trait in individuals without obstruction or inflammation. Clinical recognition of MB and its cause is important as it has been linked to behavioral disorders, learning deficits,[3] asthma morbidity,[4] distortions in jaw growth, and dental malocclusions.[5]

Mouth breathing in children can cause distortion of facial growth with deleterious effects in both the maxilla and mandible. Through muscle and soft tissue–mediated forces on the facial skeleton, MB can produce underdevelopment of the length and width of the maxilla. The response in the lower jaw is variable. The relevance of the size and shape of the maxilla to breathing (and vice versa) is that the floor of the nasal cavity and the roof of the maxilla are opposing sides of the same bony structure. From unbalanced forces of the musculature resulting from MB, the maxilla narrows in width, and forward growth can be shortened. As the maxilla narrows, the nasal cavity concomitantly narrows, increasing nasal resistance. Recent studies also show maxillary sinus narrowing.[6] If forward maxillary growth is blunted, the posterior maxillary soft palatal tissue grows forward, causing pharyngeal narrowing at the level of the nasopharynx/oropharynx junction. The soft palate is the anterior wall of the oropharynx, and this narrowing increases pharyngeal resistance. Both these detrimental narrowing changes that increase airway resistance perpetuate MB and render the pharyngeal airway more susceptible to collapse. In a child, this altered facial growth pattern reinforces MB unless multidisciplinary intervention is performed. Timing of interventions is critical as facial growth has 2 periods of increased velocity: prepubertal between 4 and 10 years and pubertal between 10 and 15 years.

Recurrence of Carly's behavioral problems after adenotonsillectomy (T&A) could signal incomplete management of a narrowed airway. While T&A can increase the size of the pharynx, an often overlooked but equally important area is the nose and nasal resistance generated from nasal cavity narrowing. Studies cite varying levels of improvement in sleep-disordered breathing (SDB) after T&A, indicating that other therapies may be needed. One such therapy is bimaxillary orthodontic expansion, which is used to treat dental crowding in children, but it is also a strategy for pediatric SDB.[7] Bimaxillary expansion can reduce nasal resistance through nasal cavity expansion that occurs with maxillary widening across the midpalatal suture. This enlargement in width can also facilitate forward jaw growth. Comprehensive management of Carly's obstructive sleep apnea (OSA) requires integrated efforts of the pediatrician, sleep physician, otolaryngologist, allergist, orthodontist, and myofunctional therapist to alleviate OSA-related attention-deficit hyperactivity disorder symptoms.

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As developmental-behavioral pediatricians, we are frequently called upon to evaluate a child for attention-deficit hyperactivity disorder (ADHD). During the evaluation, the differential diagnosis should remain broad and include medical conditions that may contribute to or be the primary cause of ADHD symptoms. In Carly's case, the medical comorbidity was obstructive sleep apnea (OSA). OSA results in nonrestorative sleep caused by disruptions to sleep, stemming from frequent, partial, or full obstruction of the upper airway, and arousals from sleep. Individuals with frequent sleep arousals are unable to achieve and/or maintain deeper stages of sleep. The result is chronic sleep deprivation and ADHD-like symptoms, behavior and mood problems, daytime sleepiness, fatigue, and poor school performance.

Obstructive sleep apnea is associated with adverse neurocognitive effects on attention, memory, and behavior.[1] For Carly, our team had the benefit of extensive neurocognitive testing, which demonstrated mixed results, some supporting, and others less supportive of ADHD. Furthermore, she was attentive during testing with a psychologist. In addition to loud breathing, snoring, and gasping, a comprehensive sleep history included questions regarding mouth breathing (MB), bruxism, enuresis, chronic nasal congestion/allergic rhinitis, and frequent or new onset of parasomnias,[2,3] as well as questions on the validated Pediatric Sleep Questionnaire.[4] Carly had both MB and snoring. On physical examination, Carly had 2+ tonsils, relatively small jaw, and high-arched palate. She had evidence of allergic rhinitis with chronic nasal congestion, which prevented her from breathing through her nose. Chronic MB affected growth of her face, resulting in a high-arched palate. Polysomnography (PSG) was obtained, as recommended by the American Academy of Pediatrics (AAP) in all children with evidence of sleep-disordered breathing.[5] It revealed that Carly had an Apnea-Hypopnea Index (AHI) of 8.2 (AHI $>$ 1.0 is abnormal in children). She underwent adenotonsillectomy (T&A) and had immediate behavioral improvement although symptoms recurred after 1 year. She had been referred to

an orthodontist for palate expansion; however, her parents declined when symptoms improved after T&A. Her pediatrician treated allergic rhinitis aggressively; when ADHD symptoms recurred, follow-up PSG showed persistent OSA. She then had palate expansion with an orthodontic device with subsequent resolution of MB.[6]

It is also important to acknowledge other potential contributors to ADHD symptoms in addition to OSA, both at the time of initial evaluation and with symptom recurrence. Carly had a biologic risk with a history of ADHD and learning disability in her father. Environmental contributors important to address include recent marital separation, multiple caregivers, and inconsistent approaches to discipline. A referral for behavior management training occurred at her initial visit and 1 year postsurgery. In preschool children, behavior management training is considered first-line treatment for ADHD as recommended in the AAP ADHD Clinical Practice Guidelines.[7] A school behavior intervention plan also contributed to improved behavior. In conclusion, we recommend comprehensive interdisciplinary assessment and management of medical and psychosocial factors associated with ADHD symptoms, coordinated through the medical home.

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Hyperactivity, inattention, and impulsivity are a cluster of frequently seen behaviors in children and adolescents that often trigger an evaluation for attention-deficit hyperactivity disorder (ADHD). This Challenging Case reminds us that there is a differential diagnosis for this behavioral triad that must be a part of each evaluation, including mental health conditions (e.g., anxiety), learning disabilities, situational change (e.g., a tumultuous divorce, spousal abuse, or child maltreatment), and environmental conditions (e.g., bullying or neighborhood violence). Numerous physical conditions can mimic ADHD, such as petit mal seizures (inattentive type of ADHD), a chronic medical illness such as severe allergic rhinitis or inflammatory bowel disease associated with chronic pain and irritability, and substance abuse. X-linked adrenoleukodystrophy can present in a school-age child with typical ADHD behaviors.

Carly's presentation is an example of the value of a complete medical history and physical examination for each patient who is evaluated for ADHD. It is also a striking example of 4 subspecialties (sleep medicine, otolaryngology, dentistry, and developmental-behavioral pediatrics) collaborating to establish the correct diagnosis and management.

There are 2 specific statements in Dr. Koltai's commentary that are especially instructive to all pediatricians: (1) symptoms of obstructive sleep apnea (OSA) include snoring, gasping, and breathing pauses while sleeping restlessly, sweating, bed wetting, waking irritably with moody mornings, and episodes of excessive daytime sleepiness, and (2) healthy children older than 3 years with symptoms and a physical examination consistent with OSA generally do not require a polysomnogram before recommending intervention.