Approach to and Evaluation of Sleep Disorders

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ABSTRACT

Purpose of Review: This article provides a framework for the clinical assessment of patients with sleep-related complaints and outlines a systematic approach to a sleep-specific history and physical examination, subjective assessment tools, and diagnostic testing modalities.

Recent Findings: Physical examination findings may suggest the presence of a sleep disorder, and obstructive sleep apnea in particular, but the clinical history remains the most important element of the assessment for most sleep problems. While nocturnal polysomnography in a sleep laboratory remains the gold standard for diagnosis of sleep-disordered breathing, out-of-center testing may be considered when the clinician has a high pretest suspicion for obstructive sleep apnea and the patient has no significant cardiopulmonary, neuromuscular, or other sleep disorders.

Summary: Sleep-related symptoms are common in adult and pediatric patients. A comprehensive sleep history, physical examination with detailed evaluation of the head and neck, and judicious use of sleep-specific questionnaires guide the decision to pursue diagnostic testing. Understanding of the benefits and limitations of various diagnostic modalities is important as the spectrum of testing options increases.

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INTRODUCTION

The NIH Sleep Disorders Research Plan,[1] updated in November 2011, indicates a 25% to 30% prevalence of sleep and circadian disorders in the general adult population. The exact prevalence of sleep disorders in neurologic disease is unknown but in some instances may be higher than in the general population. Focused assessment and management of impaired sleep or alertness may improve quality of life, improve productivity, reduce accidents, or attenuate progression of a coexisting neurologic disease or facilitate recovery from it.

SLEEP HISTORY

A detailed sleep history is the central component of the evaluation. Historical information given by the patient should, when possible, be supplemented by a bed partner, family member, or roommate who may have different insight into the patient's behavior during sleep or daytime mood and cognitive functioning. Whether the presenting sleep complaint is excessive daytime sleepiness, poor sleep quality, insomnia (difficulty falling or staying asleep), or abnormal behavior during sleep, a uniform approach to the sleep history facilitates a thorough medical decision-making process. **Table 2-1** details the essential components of the sleep history.

A chief complaint of daytime sleepiness should invite questions about its nature and severity, timing, circumstances, and possible underlying causes.

TABLE 2-1 Components of the Sleep History

- **Presenting Sleep-Related Symptom**
  - Onset
  - Precipitating/predisposing factors
  - Duration
  - Frequency
  - Severity
- **Associated Nocturnal Symptoms**
  - Sleep-disordered breathing
    - Snoring
    - Witnessed apneas
    - Morning headache
    - Mouth breathing
    - Acid reflux
    - Nasal congestion
    - Nocturia
    - Erectile dysfunction
    - Nocturnal dyspnea
  - Nocturnal behavior
    - Sleepwalking
    - Sleeptalking
    - Sleep eating
    - Leg movement
    - Dream enactment
    - Bruxism
  - Nocturnal awakenings
    - Timing in night
    - Precipitants
    - Duration
    - Frequency
    - Activities while awake
  - Other symptoms
    - Leg discomfort
    - Urge to move
    - Sleep paralysis
- **Time of Symptoms (Time During the Sleep Period That Symptoms Occur)**
- **Daytime Functioning**
  - Daytime sleepiness
  - Mood disturbance
  - Impaired school or work performance
  - Decreased alertness while driving
  - Impaired interpersonal relationships
  - Decreased concentration or memory
  - Cataplexy or hypnagogic or hypnopompic hallucinations
  - Leg discomfort, urge to move, or spontaneous movements
- **Sleep Schedule and Sleep Hygiene**
  - Bed time
  - Sleep latency
  - Wake time
  - Rise time (when patient gets up from bed)
  - Details of bedtime routine
  - Description of activities during nocturnal awakenings
- **Use of Sleep Aids and Stimulants**
  - Over-the-counter (including herbal) agents
  - Prescription medications
  - Caffeine
  - Energy drinks

Sleepiness is thought to result from neurobiologic processes that regulate circadian rhythms and the drive to sleep,[2] and some individuals will clearly articulate sleepiness as a tendency to doze unintentionally. Fatigue is defined as "reversible, motor, and cognitive impairment with reduced motivation and desire to rest,"[3] and is postulated to represent a process that is distinct from sleepiness. However, patients often interchangeably use the terms "tiredness," "sleepiness," and "fatigue."[3,4] Patients with obstructive sleep apnea (OSA), and possibly other sleep disorders associated with daytime sleepiness, may

KEY POINTS

- Information from the patient, medical record, and any available bed partner, friend, or family member can clarify the extent and consequences of the patient's sleep-related symptoms.
- The 3P framework of insomnia comprises predisposing, precipitating, and perpetuating factors. Discussion of all factors facilitates identification of potential treatment targets.

report fatigue, tiredness, or lack of energy at times even when they deny sleepiness.[4] Interestingly, these symptoms (like sleepiness) appear to improve with treatment of the underlying OSA.[5] A clear understanding of whether the patient experiences an overwhelming urge to sleep during the day may help the clinician decide which diagnostic studies to pursue, and also guides discussion about potential diagnoses that may contribute to the patient's symptoms. Special attention should be paid to situations in which the patient's sleepiness becomes evident. Does the patient doze during conversation, while at work, or while driving? Is the patient's concentration or memory impaired because of sleepiness? Dozing while operating heavy machinery or a motor vehicle can lead to devastating outcomes, and this has both individual and public health implications. Daytime sleepiness that impairs a patient's functional capabilities can threaten job security and have a negative impact on interpersonal relationships. The context of a patient's daytime sleepiness highlights its severity and impact.

The symptom of insomnia is defined as difficulty with sleep initiation or maintenance, waking too early, or sleep that is nonrestorative, despite ample opportunity to sleep.[6] Disorders that cause insomnia have diagnostic criteria to specify that the insomnia symptoms should be accompanied by at least one manifestation of daytime impairment (such as fatigue, mood disturbance, headaches, or gastrointestinal symptoms in response to sleep loss), or impaired memory, concentration, or performance. The point prevalence of insomnia is estimated at 6% to 15% in the general population but is clearly higher among certain subgroups, such as patients with psychiatric disease.[7] Population-based studies done with varied adult samples from multiple countries indicate that approximately 30% of the general adult population reports one or more insomnia symptom.[8] Because insomnia is so common, neurologists routinely encounter patients with the symptom. As the etiology of insomnia is often multifactorial, the evaluation can be complex and requires a detailed history that explores many potential contributors.

A helpful framework in which to consider a patient's insomnia is known as the "3P" model,[9] which aids identification of possible causes of insomnia and highlights potential targets for treatment. This model calls for temporal classification of factors that affect a patient's insomnia: characteristics that *predispose* a person to develop insomnia, events that *precipitate* the insomnia acutely, and behaviors and attitudes that *perpetuate* insomnia and may cause it to become chronic. Common predisposing factors include personality traits, such as excessive worrying or cognitive hyperarousal, or the degree to which a person's preferred sleeping times differ from social norms.[9] Precipitating factors are often readily identified as major life transitions, such as change in marital status, death in the family, or change in employment. However, subtler challenges to a person's routine or environment may also precipitate the onset of insomnia. In some situations, the patient's sleep normalizes upon resolution of the precipitant; in other cases, behaviors and mindsets accrued during the acute phase of the insomnia can perpetuate the patient's sleep disturbance. Such perpetuating factors can include perceived associations between the sleeping environment and inability to sleep or escalated use of caffeine throughout the day. Other important details include specifics about the patient's insomnia at the present time, including the latency to sleep; timing, duration, and causes of

Case 2-1

A 44-year-old man with a long-standing history of loud, frequent snoring presented because of his wife's concerns related to his snoring. His wife had witnessed him to have occasional pauses in his breathing during sleep, and at times he awakened to his snoring. He reported frequent acid reflux and morning headaches. Approximately once per month he would awaken ''feeling like my heart is racing and I need to catch my breath.'' He had occasional nasal congestion but always awakened with a dry mouth and sore throat. He denied any leg discomfort, but his wife had told him that he tossed and turned frequently during sleep.

His sleep schedule was the same every night: he was in bed by 10:00 PM, fell asleep immediately without the use of any sleep aids, and awakened at 6:00 AM feeling tired. He had up to four nocturnal awakenings per night; two were attributed to nocturia and the rest were of unknown etiology. Each awakening lasted a few minutes, and he fell asleep again easily. He had had a few episodes of sleepwalking as a child, but none since the age of 8 years.

He felt sleepy during the day, with a propensity to doze unintentionally while reading or watching television. He denied drowsiness while driving but limited his driving to his 20-minute commute to and from work; his wife drove for longer distances and he would often sleep in the passenger seat. His sleepiness was worse in the midafternoon, and if given the opportunity he would nap for 1 hour on the weekends. He found naps to be somewhat refreshing. He drank two to three cups of coffee every morning and had a 12-oz caffeinated soda with lunch. His sleepiness had not caused him to make any mistakes in his job as a physical therapist, although he felt that he had potential for further improvement in his job performance. He also reported feeling more irritable in recent months, but this had not caused any difficulties at home or work.

Comment. This case illustrates the multiple components of a concise but still detailed sleep history. The patient's daytime symptoms provide insight about the effects of the patient's untreated sleep disorder.

nocturnal awakenings; behaviors during nocturnal awakenings; and latency to fall back asleep after each awakening. A useful approach is to ask the patient for a detailed, start-to-finish description of the entire typical sleep period and daytime period. Any medications previously or currently used to facilitate sleep should also be identified.

The sleep history should screen for potentially relevant sleep disorders that may cause excessive daytime sleepiness or insomnia (**Case 2-1**). The presence of symptoms such as snoring, witnessed apneas, and morning headaches raises the suspicion for sleep-disordered breathing (SDB). Leg discomfort associated with an urge to move that worsens at night and improves with leg movement indicates restless legs syndrome and may contribute to the patient's poor sleep quality and impair daytime functioning. Sleep paralysis and hypnagogic or hypnopompic hallucinations are not specific to a particular sleep disorder, while a history of cataplexy is pathognomonic for narcolepsy and must be explored when a patient presents with reports of central hypersomnia rather than SDB. When relevant, the clinician should also ask about nocturnal behaviors, specifically ones that may pose risk of injury to the patient or bed partner,

KEY POINT

- Details of facial morphology, nasal airway patency, and oral airway crowding are key features of the sleep-specific examination.

such as sleepwalking, driving or cooking while asleep, or dream-enactment behavior. If the patient reports such behavior, further inquiry must be made about the frequency of these events and any history of injury sustained due to the sleep-related behavior. Details of the sleep history permit a thorough differential diagnosis and can also guide a discussion of safety concerns.

PHYSICAL EXAMINATION

A comprehensive, multisystem examination is an important aspect of the sleep evaluation. Measurement of the weight, height, body mass index (BMI), neck circumference, and blood pressure and heart rate should be performed for nearly all patients with symptoms related to sleep or alertness. Other salient features of the general examination include auscultation for any cardiac or respiratory abnormalities and identification of peripheral edema. A focused neurologic examination should be guided by the patient's history. For instance, a mental status assessment should be considered if a patient with excessive daytime sleepiness also complains of memory loss. If a patient with a history of diabetes mellitus endorses symptoms of restless legs syndrome, it is worthwhile to assess for stocking-glove distribution sensory loss and weakness.

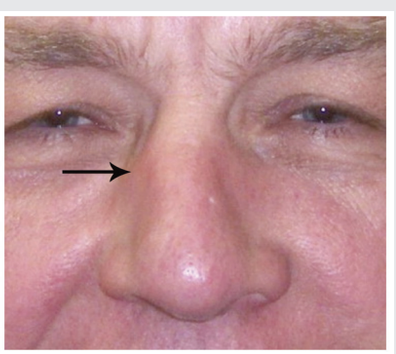

FIGURE 2-1 Nasal septal deviation. This structural abnormality can predispose a patient to have sleep-disordered breathing.

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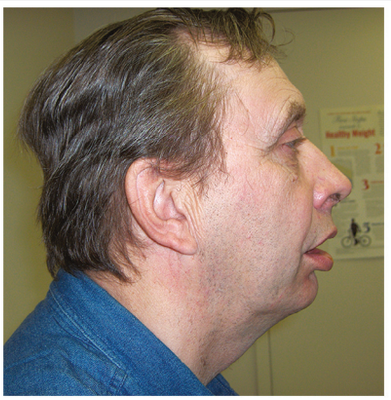

FIGURE 2-2 Retrognathia. Retrognathia is derived from the terms ''retro'' (backward) and ''gnathos'' (jaw). With retrognathia, one or both jaws recede with respect to the frontal plane of the forehead. The condition may predispose a patient to obstruction of the airway and sleep apnea by displacing the tongue against the retropharyngeal region, compromising airflow. Retrognathia is sometimes corrected through surgical repositioning or advancement of the mandible.

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Detailed examination of the head and neck should be performed as part of a comprehensive sleep evaluation. The patient's facial morphology should be assessed for features of long face syndrome, which includes infraorbital darkening, mouth breathing, elongated midface, and nasal atrophy.[10] A 2009 review[11] reports that previous observational and cross-sectional studies have shown a relationship between chronic nasal obstruction and OSA. Thus, a thorough nasal examination should be performed on patients with sleep-related complaints. Examination of the nasal airway should include evaluation for symmetry of the nares, nasal septum deviation (**Figure 2-1**),[12] and nasal turbinate hypertrophy. A bedside assessment of nasal airflow can be accomplished by

asking the patient to press the index finger against the left nostril and take a deep breath in on the right side; this should be repeated on the opposite side as well. The patient's facial morphology should be assessed for mandibular retrognathia (**Figure 2-2**).[12] With the patient's head in a neutral position, a virtual line is drawn from the vermillion border of the lower lip to the chin. Mandibular retrognathia is suggested if the anterior prominence of the chin is 2 mm or more behind the virtual line.[13]

The modified Mallampati classification is commonly used for assessment of the oral airway in patients with suspected SDB. The Mallampati classification[14] was developed to identify patients in whom tracheal intubation would be difficult; the initial description divided patients into three classes. Two years later,[15] this was modified to describe four groups: class I, class II, class III, and class IV. **Figure 2-3** [16] illustrates the modified Mallampati classification assessed with the tongue protruded. The Friedman palate position classification,[17] also commonly referenced, utilizes the same four categories but is done with the tongue at rest and not extended. Either the Mallampati or Friedman classification may be used to describe the patency of the oral airway.

Tonsils should be classified based on the degree of hypertrophy (**Figure 2-4**)[12]: grade I, tonsils are inside the tonsillar fossa lateral to the posterior pillars; grade II, tonsils occupy 25% of the oropharynx; grade III, tonsils occupy 50% of the oropharynx; and grade IV, tonsils occupy at least 75% of the

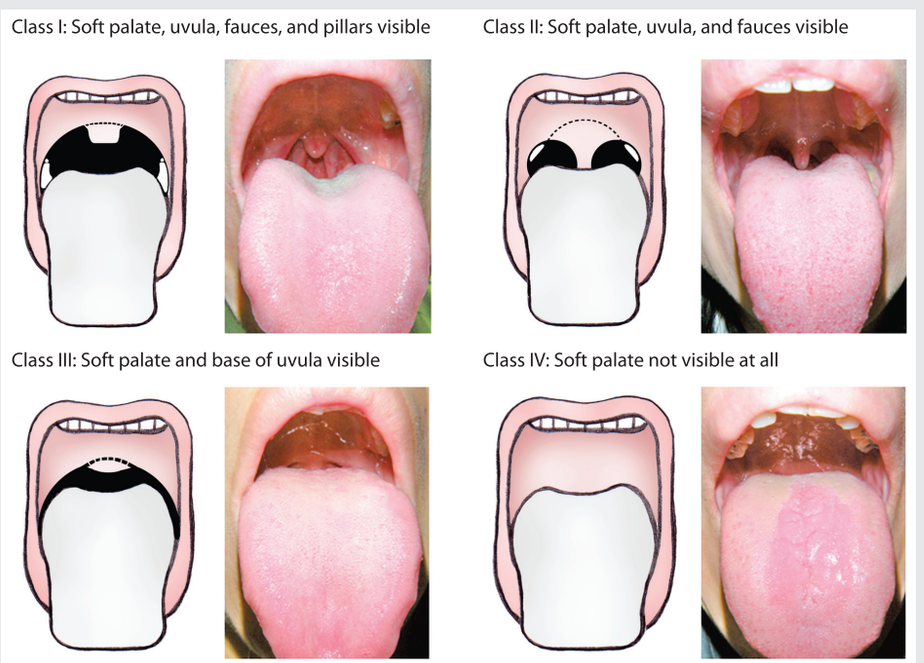

FIGURE 2-3 Modified Mallampati classification. The class is determined by looking at the anatomy of the oral cavity and describes tongue size relative to oropharyngeal size. The test is conducted with the patient seated, the head held in a neutral position, and the mouth wide open and relaxed. The subsequent classification is assigned based upon the pharyngeal structures that are visible.

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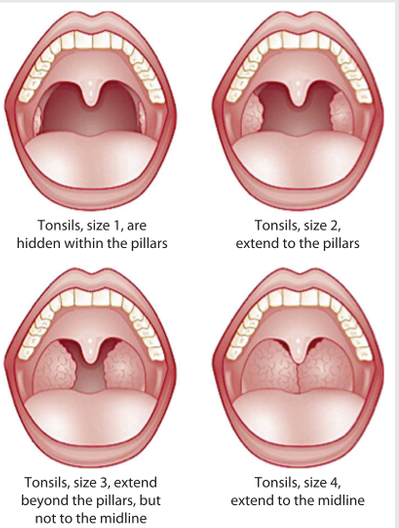

FIGURE 2-4 Tonsil size grading. This structural abnormality can predispose a patient to have sleep-disordered breathing.

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oropharynx and nearly meet in the midline.[13] A high-arched, narrow hard palate (**Figure 2-5**)[18] may predispose the patient to have SDB. Katz and colleagues[19] have shown that patients with OSA have significantly increased neck circumference compared to nonapneic snorers; greater distribution of neck fat may contribute to mass loading on the upper airway in patients with OSA. The patient's neck circumference should be measured at the superior border of the cricothyroid membrane.[19] A neck circumference greater than 40 cm (15.7 in) has been shown to be predictive of OSA with 61% sensitivity and 93% specificity, regardless of sex.[20]

Assessment of the patient's anterior and posterior dentition can also reveal anatomic findings that may predispose a person to certain sleep disorders. Two features to note in evaluation of the anterior dentition are overjet and overbite (**Figure 2-6**).[21] Overjet, as shown in **Figure 2-7**,[12] is the horizontal distance between the upper right central incisor and the buccal surface of the corresponding lower tooth, while overbite is the vertical distance between these two points.[22] These measurements are typically reported in millimeters. The Angle classification system is used to describe the first molar position on

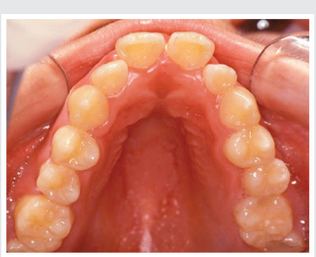

FIGURE 2-5 Deficient maxillary development in an individual with Down syndrome leading to high and narrow hard palate.

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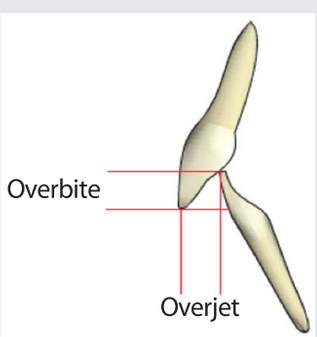

FIGURE 2-6 Overjet and overbite. Overjet is defined as increased projection of the upper teeth in front of the lower teeth as measured parallel to the occlusal plane. Overbite is the vertical overlapping of maxillary teeth over mandibular teeth, usually measured perpendicular to the occlusal plane.

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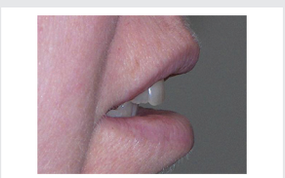

FIGURE 2-7 Overjet. Displacement of the mandibular teeth posteriorly in relationship to the maxillary teeth results in more posteriorly crowded upper airways, predisposing patients for the development of obstructive sleep apnea.

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the mandibular and maxillary dental arches.[23] **Figure 2-8** shows class I occlusion and class II and III malocclusion. Of note, the mesiobuccal surface is the aspect of the tooth that is adjacent to the cheek mucosa.

The Adult Obstructive Sleep Apnea Task Force of the American Academy of Sleep Medicine (AASM) recommended in recent clinical guidelines[24] that the following physical findings may suggest the presence of OSA: increased neck circumference (greater than 43.2 cm [17 in] in men, greater than 40.6 cm [16 in] in women), BMI 30 kg/m^2 or greater, modified Mallampati classification of III or IV, presence of retrognathia, lateral peritonsillar narrowing, macroglossia, tonsillar hypertrophy, elongated/enlarged uvula, high-arched/narrow hard palate, nasal abnormalities (eg, polyps, deviation, valve abnormalities,

KEY POINT

■ Classification of the patient's dentition helps to evaluate the position of the maxillary arch relative to the mandibular arch.

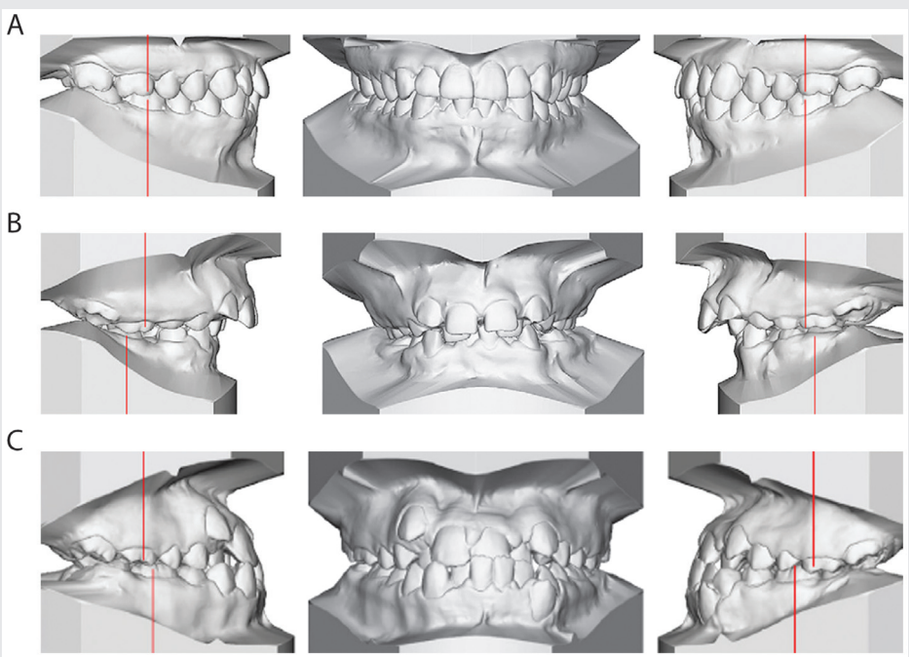

FIGURE 2-8 Angle class occlusion/malocclusion. *A*, Angle class I occlusion, also known as neutrocclusion. The mandibular and maxillary dental arches have a normal anterior-posterior relationship. The mesiobuccal groove of the mandibular first molar interdigitates with the mesiobuccal cusp of the maxillary first molar. *B*, Angle class II malocclusion, also known as distoclusion. The mandibular dental arch is in distal anterior-posterior relationship to the maxillary dental arch. The mesiobuccal groove of the mandibular first molar is distal to the mesiobuccal cusp of the maxillary first molar. *C*, Angle class III malocclusion, also known as mesioclusion. The mandibular dental arch is in mesial anterior-posterior relationship to the maxillary dental arch. The mesiobuccal groove of the mandibular first molar is mesial to the mesiobuccal cusp of the maxillary first molar.

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KEY POINTS

- The Epworth Sleepiness Scale, a patient-completed questionnaire, assesses the patient's subjective tendency to doze during sedentary situations in recent times, not only at the moment the questionnaire is completed.
- The Epworth Sleepiness Scale should not be used in lieu of diagnostic testing but may be a valuable component of ongoing clinical evaluation.

and turbinate hypertrophy), and/or overjet. To prevent overlooking these findings, a thorough head and neck assessment as described in **Table 2-2** should be incorporated into the physical examination of all patients who present with sleep-related complaints.

SUBJECTIVE ASSESSMENT

Several patient-completed questionnaires are inexpensive and time-efficient, reasonably well validated, and commonly used. They can help to increase standardization in evaluations of patients by different clinicians or across centers. Perhaps the most well-known and widely used is the Epworth Sleepiness Scale,[25] a subjective assessment of the patient's daytime sleep propensity in recent times. As shown in **Appendix A**, the Epworth Sleepiness Scale asks the responder to use a four-point Likert scale (0, 1, 2, or 3) to indicate the likelihood of dozing in eight distinct sedentary conditions. A total score of 10 or greater, out of a possible 24, suggests excessive daytime sleepiness.[25] While the Epworth Sleepiness Scale score can be easily incorporated into the clinical evaluation, it should not be used as a substitute for objective measurement of sleepiness. The Epworth Sleepiness Scale score may correlate to a limited extent with the presence and severity of OSA,[26] but some studies have failed to find any statistically significant association with mean sleep latency on multiple sleep latency tests, or with severity of OSA.[27] The most advantageous use of the Epworth Sleepiness Scale may be to follow an individual's self-assessment of sleepiness longitudinally, and it may also serve as an indicator of treatment response.

Many other questionnaires may be utilized in a clinical sleep evaluation; some pertain to overall sleep quality, while others are disorder-specific. The Patient Reported Outcomes Measurement Information System (PROMIS) is an NIH-supported system of measures for patient-reported health status and includes questions on sleep disturbance. The Pittsburgh Sleep Quality Index (PSQI) is a validated questionnaire that inquires about sleep quality and disturbances over the previous month.[28] The parent-completed Pediatric Sleep Questionnaire[29] contains a validated, reliable 22-item scale to help assess risk for SDB in children.

TABLE 2-2 Head and Neck Examination

▶ **Face**
Features of long face syndrome
Infraorbital darkening
Mouth breathing
Elongated midface
Nasal atrophy
▶ **Oral Airway**
Mandibular retrognathia
Low soft palate (modified Mallampati classification)
Large or boggy uvula
Erythematous pillars
Tonsillar hypertrophy
High, narrow hard palate
Neck circumference
Overjet
Overbite
Angle classification (malocclusion)
Macroglossia
Worn occlusive surfaces (suggestive of bruxism)
▶ **Nasal Airway**
Symmetry of the nares
Nasal septum deviation
Nasal airflow
Collapse of nasal alae on inspiration
▶ **Neck**
Neck circumference

The STOP-BANG questionnaire, developed and validated in preoperative patients, is a sensitive screening tool for OSA. Four questions address snoring, tiredness during daytime, observed apnea, and high blood pressure, whereas four other measures focus on increased OSA risk factors of BMI (greater than 35 kg/m^2), age (older than 50 years), neck circumference (greater than 40 cm [15.75 in]), and gender (male prevalence).[30] The International Restless Legs Syndrome Study Group Rating Scale (IRLS) is a validated assessment of disease severity for patients with restless legs syndrome.[31] The patient's perceived level of insomnia may be assessed with the Insomnia Severity Index (ISI), a validated 7-item questionnaire.[32]

A sleep diary (**Figure 2-9**)[33] allows a patient to chart daily sleep and wake times and should be maintained for at least 2 consecutive weeks. Review of this information allows the clinician to estimate the total amount of sleep the patient obtains in a 24-hour period. The sleep diary also can provide insight into the patient's sleep pattern. Is sleep obtained at the same times every day? Is the patient's sleep consolidated or fragmented across 24 hours? Does the patient sleep and

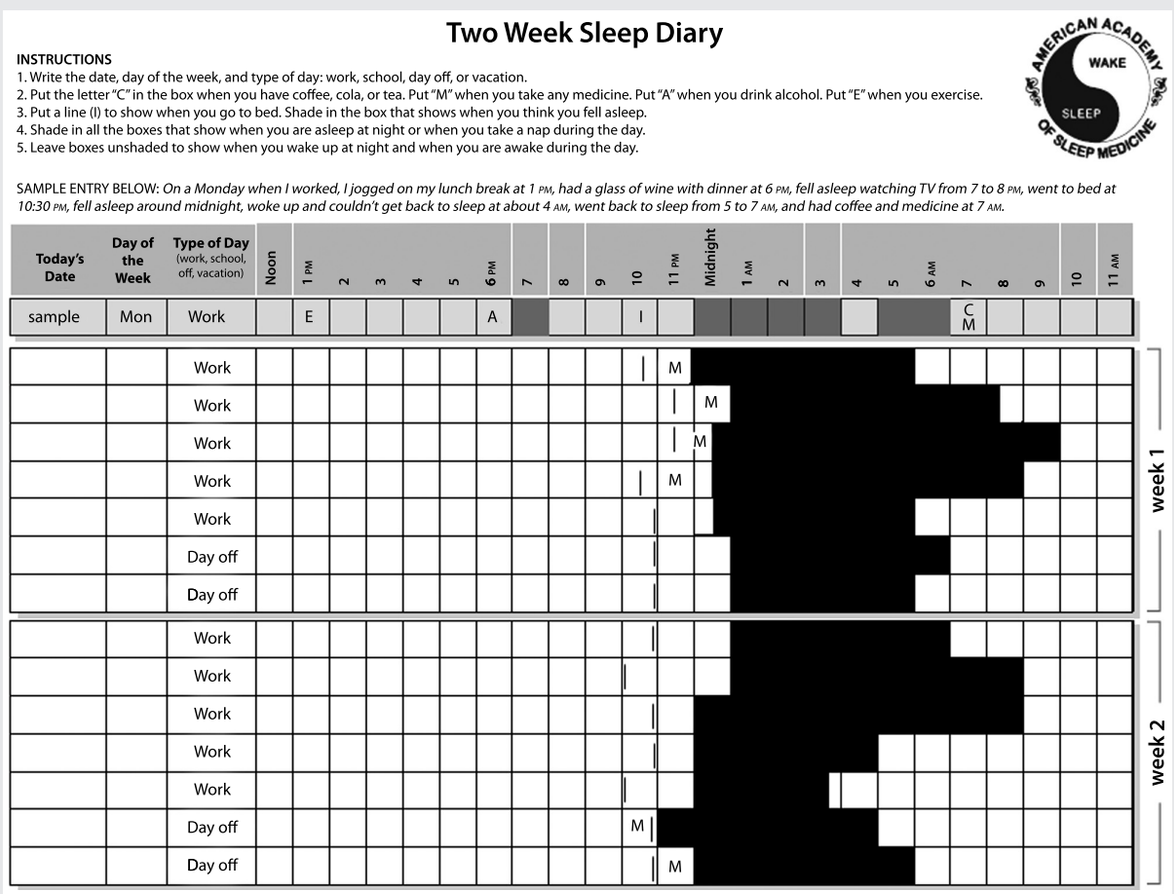

FIGURE 2-9 Sleep diary completed by a 46-year-old woman who presented with difficulty falling asleep. *Vertical lines* represent when the patient went to bed, ''*M*'' refers to when medication was taken, *black shading* represents time asleep, and *unshaded white areas* are time spent awake.

Diary template reprinted from YOURSLEEP.aasmnet.org from the American Academy of Sleep Medicine, *yoursleep.aasmnet.org/pdf/sleepdiary.pdf*.[33]

KEY POINT

- A daily sleep diary helps to summarize a patient's sleep-wake schedule more accurately than memory often allows and can facilitate construction of personalized plans for management of circadian rhythm sleep disorders and insomnia.

wake at conventional times, or does he or she appear to be a "night owl" or "morning lark?" Answers to these questions, as provided by the sleep diary, may reveal factors that contribute to sleep-related concerns. Use of sleep diaries can be particularly helpful in patients with suspected circadian rhythm sleep disorders (including shift work), behaviorally induced insufficient sleep, or inadequate sleep hygiene.

OBJECTIVE MEASURES

Nocturnal polysomnography (NPSG) or related assessments are indicated for the diagnosis and assessment of SDB, and for positive airway titration in patients with confirmed SDB. The procedure can also provide information about EEG activity, nocturnal movements, cardiac rhythm, and oxygen saturation.[34] The recommended recording montage used in NPSG, as shown in **Figure 2-10**, includes central (C3-A2, C4-A1), frontal (F3-A2, F4-A1), and occipital (O1-A2, O2-A1) EEGs, left and right eye electrooculograms, mental/submental surface EMG, and ECG leads. Other recorded parameters include thoracic and abdominal effort, oxygen saturation, nasal/oral airflow, and body position. Use of a microphone to record snoring is recommended but not required.[34] A full, 16-lead EEG (**Figure 2-11**)[35] and video recording may be performed when nocturnal seizures are suspected. Leg surface EMG leads are recommended, and additional arm EMG leads may be applied when the clinical history suggests complex sleep-related motor behaviors, such as dream enactment. In

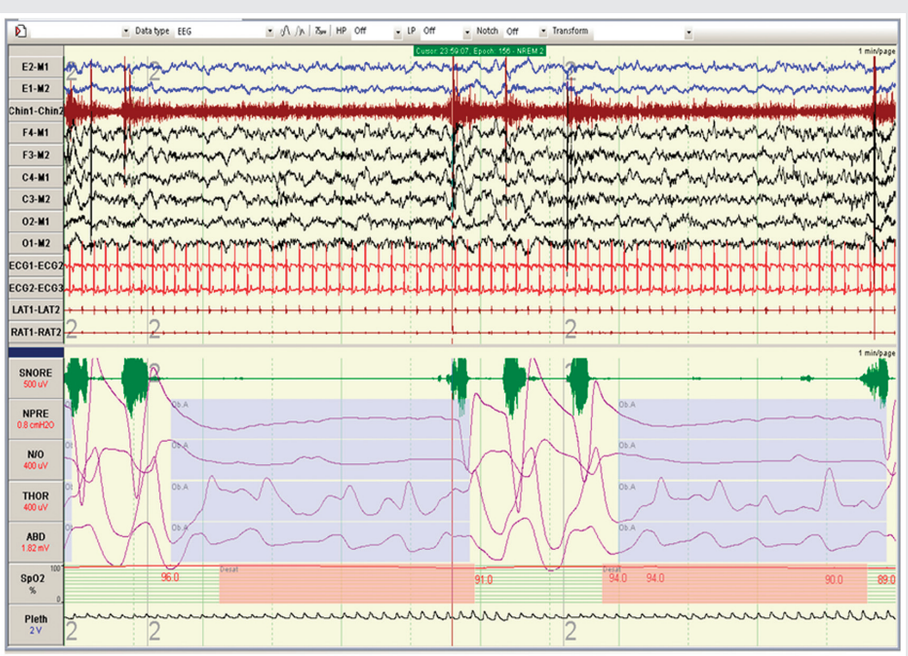

FIGURE 2-10 A 1-minute epoch from a nocturnal polysomnogram showing obstructive sleep apnea in a 46-year-old man who presented with snoring, daytime sleepiness, and headaches. It depicts the standard recording montage that includes the following leads: central (C3-M2, C4-M1), frontal (F3-M2, F4-M1), and occipital (O1-M2, O2-M1) EEGs; left and right eye electrooculograms (E1-M2, E2-M1); mental/submental electromyogram (Chin1-Chin2); electrocardiogram (ECG1-ECG2, ECG2-ECG3); snore volume (SNORE); nasal pressure transducer (NPRE); nasal/oral airflow (N/O); thoracic (THOR) and abdominal (ABD) effort; arterial oxyhemoglobin saturation (SpO2); plethysmography (Pleth); and left and right eye electromyograms (LAT1-LAT2, RAT1-RAT2).

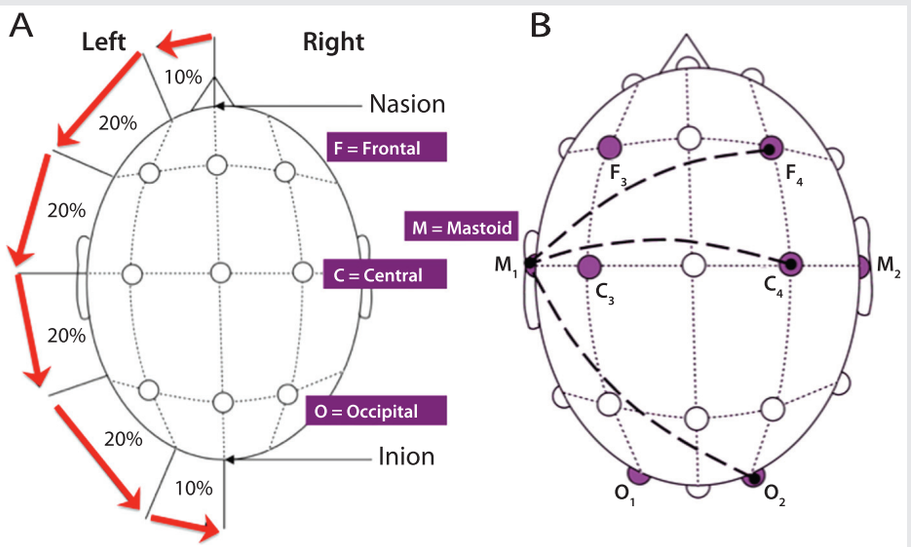

FIGURE 2-11 *A*, The international 10–20 system for EEG electrode placement refers to the 10% and 20% interelectrode distances. Even electrode numbers (2, 4, 6, 8) represent the right hemisphere, and odd electrode numbers (1, 3, 5, 7) represent the left hemisphere. *B*, Recommended F4-M1, C4-M1, O2-M1 placements of EEG electrodes as set forth by the American Academy of Sleep Medicine (AASM).

Adapted from Iber C et al, American Academy of Sleep Medicine.[35] Used with permission of the American Academy of Sleep Medicine, Darien, IL, 2012.

most cases the diagnostic NPSG is done on 1 night, although NPSG on 2 consecutive nights may be considered in the evaluation of parasomnias.

Four categories of sleep monitoring devices for use in the diagnosis of sleep disorders have often been described.[34] These are type 1, standard, attended, in-laboratory polysomnography; type 2, comprehensive portable, unattended polysomnography; type 3, modified portable sleep apnea testing (often cardiorespiratory studies that do not record sleep); and type 4, continuous single or dual bioparameter recording (eg, pulse oximetry). However, this categorization may not effectively classify the plethora of out-of-center testing devices currently available for clinical use. Therefore, a new device classification system has recently been proposed. This schema, known as the SCOPER system, categorizes out-of-center testing devices based on measurement of sleep, cardiovascular, oximetry, position, effort, and respiratory parameters.[36] Within each of the six SCOPER categories, a level of 0 through 5 is assigned as indicated by the type of sensor or measurement that the device uses for that category.

The most recent clinical guidelines, published by the Portable Monitoring Task Force of the AASM[37] for use of unattended portable monitoring in the diagnosis of OSA in adult patients, recommend that portable monitoring only be performed in conjunction with a comprehensive sleep evaluation by (or supervised by) a practitioner board-certified in sleep medicine or eligible for the certification examination. These guidelines state that portable monitoring may be used in place of NPSG in patients with a high pretest probability of moderate to severe OSA. Portable monitoring should not be used in patients with significant medical comorbidities (including, but not limited to,

KEY POINT

- The complex classification of portable testing devices reflects the multitude of designs available to clinicians and will undoubtedly change as technology advances.

KEY POINT

- Careful consideration should be given to the indications for out-of-center testing. Attended nocturnal polysomnography is indicated if a portable study yields a negative or technically inadequate result.

moderate to severe pulmonary disease, neuromuscular disease, or congestive heart failure), in patients with other sleep disorders (including central sleep apnea, periodic limb movement disorder, insomnia, parasomnias, circadian rhythm disorders, or narcolepsy), or as a screening tool. The use of portable monitoring may be indicated for the diagnosis of OSA in patients for whom attended NPSG is not possible because of immobility, safety, or critical illness. Portable monitoring may be indicated to monitor the response to noncontinuous positive airway pressure treatments for OSA, including oral appliances, upper airway surgery, and weight loss. The algorithm shown in **Appendix B** may help in the determination of an adult patient's candidacy for out-of-center testing for the diagnosis of OSA. An example of portable (or home) monitoring technology is shown in **Supplemental Digital Content 2-1**, *links.lww.com/CONT/A15*.

Recommended technology for portable monitoring should record, at minimum, airflow, respiratory effort, and blood oxygenation; the airflow, effort, and oximetric biosensors typically used for attended NPSG should be used.[37] These guidelines, published in 2007, will likely continue to evolve as new technologies emerge and are found to be effective. The current guidelines recommend that out-of-center testing be performed under the auspices of an AASM-accredited comprehensive sleep medicine program and that a board-certified/eligible sleep specialist review the raw data from a portable monitoring device. All patients who undergo portable monitoring for the diagnosis of OSA should have a follow-up visit to review test results. Negative or technically inadequate portable monitoring studies should be followed by attended, in-laboratory NPSG if the clinical suspicion for SDB remains high.[37]

The aforementioned testing procedures are primarily used in the evaluation of SDB. Other testing modalities are useful in the diagnosis of other categories of sleep disorders. The multiple sleep latency test (MSLT) and its variant, the maintenance of wakefulness test (MWT), are used in the evaluation of hypersomnia. The conventional recording montage is similar to that used for nocturnal polysomnography: central, frontal, and occipital EEGs, left and right eye electrooculograms, mental/submental EMG, and ECG leads. Measurement of thoracic and abdominal effort, oxygen saturation, and nasal/oral airflow are not required but may help explain delayed sleep latencies for patients in whom respiratory disturbances interfere with sleep onset.

The MSLT is a validated tool that is considered the de facto standard for objective assessment of excessive daytime sleepiness.[38] The recommended protocol[38] involves five 20-minute nap opportunities held at 2-hour intervals throughout the day. If sleep is observed, the patient is allowed to sleep for at least 15 minutes. The sleep latency for each nap is measured as the time from the start of the nap trial to the first epoch of sleep. A sleep latency of 20 minutes is assigned to nap trials during which no sleep is observed.[39] The mean sleep latency, calculated as the average sleep latency across all nap trials, is the final result. The presence and number of sleep-onset REM periods (SOREMPs) is also determined, as this information can help to establish a diagnosis of narcolepsy without cataplexy or to confirm narcolepsy with cataplexy.

The MSLT should be started 1.5 to 3.0 hours following completion of a nocturnal polysomnogram, which should record at least 6 hours of sleep in order for determination of the mean sleep latency to be valid. Drugs that may

interfere with sleep latency or REM latency should be discontinued 2 weeks before testing, whenever possible. A screen may be performed on the day of testing if there is suspicion that prescribed or illicit substances may contribute to the patient's sleepiness.[38]

No large, multicenter, systematically collected normative data are available for mean sleep latency values on the MSLT.[38] Nonetheless, a mean sleep latency of greater than 10 minutes is often considered normal, whereas a mean sleep latency of 8 to 10 minutes is considered a physiologic gray zone.[40] The normative data for children are classified by Tanner stage of development, though the MSLT is typically not performed in children aged younger than 6 or 7 years because some daytime napping may still be normal in young children.[41] The second edition of the *International Classification of Sleep Disorders: Diagnostic and Coding Manual* (*ICSD-2*)[42] requires the presence of a mean sleep latency of less than 8 minutes and two or more SOREMPs as part of the diagnostic criteria for narcolepsy without cataplexy. However, the *ICSD-2* also notes that a mean sleep latency of less than 8 minutes may occur in up to 30% of the general population. Therefore, while the MSLT is a helpful and widely used tool, it remains an imperfect gold standard in the assessment of daytime sleepiness. This necessitates that the evaluation of daytime sleepiness not rest on the MSLT results alone but assimilate the clinical history, subjective complaints, diagnostic study results, and other pertinent medical information.[38]

Practice parameters from the AASM state that the MSLT is indicated for diagnostic confirmation of suspected narcolepsy and may be indicated to differentiate idiopathic hypersomnia from narcolepsy.[38] The MSLT is not indicated for routine assessment of OSA syndrome or to assess response to treatment of SDB, and is not routinely indicated for evaluation of sleepiness in medical or neurologic disorders (except for narcolepsy), insomnia, or circadian rhythm disorders.

The MWT provides an objective measure of a patient's ability to remain awake, rather than the tendency to fall asleep, during the day. The key difference between the MWT and the MSLT is that in the former, the patient is asked to try to stay awake under circumstances conducive to sleep, rather than to fall asleep. The MWT provides an objective, validated assessment of the ability to remain awake for a defined length of time.[38] The recommended protocol includes four 40-minute trials that begin at 2-hour intervals, with the first trial to start 1.5 to 3.0 hours after the patient's wake-up time. A nocturnal polysomnogram on the preceding night is not required. However, the patient should obtain a sufficient amount of sleep during the night before the MWT. Each trial is terminated after 40 minutes if no sleep occurs, or after unequivocal sleep onset (defined as three continuous epochs of stage N1 sleep or one epoch of any other stage of sleep) has occurred.[38] One indication for the MWT is to assess an individual's ability to remain awake when his or her inability to remain awake constitutes a public or personal safety issue. This can become a pressing issue for individuals employed in the transportation,[43] construction, or health care industries. The MWT may be indicated to assess treatment response in patients with known excessive daytime sleepiness.

Limited amounts of normative data are available for the MWT. Historically, multiple testing protocols make synthesis of results more challenging. The MWT is used much less often in clinical practice compared to the MSLT. Patient

KEY POINTS

- The multiple sleep latency test is the gold standard for objective assessment of daytime sleepiness, but interpretation of the results must be made within the clinical context of the patient's history.
- In the multiple sleep latency test, the patient is instructed to try to sleep during each nap trial. In the maintenance of wakefulness test, the patient is instructed to try to remain awake during the nap trial.
- A baseline nocturnal polysomnogram is required before a multiple sleep latency test and considered, but not required, before a maintenance of wakefulness test.

KEY POINTS

- Actigraphy can be useful in evaluation and treatment of circadian rhythm sleep disorders and in management of insomnia.
- Neuroimaging is not routinely indicated in the clinical evaluation of sleep disorders and should be pursued on a case-by-case basis.

age may also affect the mean sleep latency values on both the MWT and the MSLT[43] and may represent evolution of circadian rhythm and sleep architecture across the lifetime. A study of 383 patients with narcolepsy with cataplexy examined the clinical and polysomnographic data at the time of diagnosis (age range 5 to 84 years) and found a progressive decrease in the number of SOREMPs and a progressive increase in the mean sleep latency on the MSLT as a function of age.[44] Given its limitations, the MWT may thus be used to supplement the clinical history in the assessment of ability to stay awake but should not be the sole determinant of this parameter.

Actigraphy is also used in the clinical evaluation of patients with sleep disorders, particularly circadian rhythm sleep disorders. An actigraph is a watchlike device that is worn on the wrist for an extended period, usually in the range of weeks. The actigraph records movement and uses an algorithm to estimate the amounts of sleep and wake time during the recording period. Analysis software uses movement to estimate when sleep and wakefulness have occurred. Review of the data can provide objective insight into the patient's sleep pattern, including timing and duration of major sleep disruptions. Actigraphy is indicated as part of the evaluation of patients with advanced sleep-phase syndrome, delayed sleep-phase syndrome, and shift work disorder and may be indicated in the evaluation of jet lag disorder and non–24-hour sleep-wake syndrome, including that associated with blindness.[45] It can also serve as a measure of treatment response in patients with insomnia and circadian rhythm sleep disorders. For populations in which traditional sleep monitoring may be challenging, such as pediatric or older adult patients, actigraphy may provide valuable information about the patient's sleep pattern or response to treatment. When polysomnography is not available, actigraphy is indicated to estimate total sleep time in patients with OSA.[45]

OTHER ASSESSMENT MODALITIES

Laboratory evaluation and neuroimaging with either CT or MRI may be considered on an individual basis as indicated by the clinical history. Complete blood count (CBC), serum chemistries, or measures of thyroid function may be obtained if an underlying medical disorder is thought to contribute to the patient's sleep symptoms. For instance, these laboratory studies may be considered when daytime fatigue is a predominant symptom. Serum iron studies, including ferritin level, should be checked in patients with restless legs syndrome.[46] Neuroimaging should be considered in patients with antecedent trauma, or for any sleep disorder patient with an abnormal neurologic examination, to evaluate for a structural etiology of the patient's symptoms.

APPROACH TO THE PATIENT

Evaluation of suspected sleep disorders is best accomplished by a stepwise, multidimensional approach (**Case 2-2**). A thorough sleep history includes detailed description of sleep-related symptoms, nocturnal behaviors, the patient's sleep schedule, level of daytime sleepiness, and subsequent effects on daytime functioning. Collateral history from the patient's bed partner or family is often necessary to understand the severity and context of the patient's symptoms. Subjective assessments of sleepiness, such as the Epworth Sleepiness Scale, are easily administered and useful to track symptomatic progression or treatment response from one visit to the next. Certain physical examination findings may also raise clinical suspicion of

Case 2-2

A 23-year-old woman reported a 4-year history of insomnia. Throughout college she was a ''night owl,'' never scheduled classes that started before 1:00 PM, and always did well in school. During the past 6 months, she developed progressive difficulty staying awake in her job as a financial analyst and was concerned about how this might affect her job performance.

During the week she was in bed by midnight but was unable to fall asleep until 2:00 AM and awoke with difficulty to an alarm at 6:00 AM, feeling tired. She denied any thought rumination or physical discomfort at bedtime. She had tried over-the-counter sleep aids that provided no symptomatic improvement and worsened morning grogginess. On weekends she slept from 2:00 AM to 11:00 AM and awakened feeling ''pretty good.'' She had nocturia up to once per night and occasional morning headaches. She had no bed partner but reported gasping respirations, nocturnal palpitations, and snort arousals. On about 4 nights per week, she experienced a sensation of needing to move her legs while trying to fall asleep. This sensation was relieved by movement and was worse at night than during the day. Her legs sometimes moved spontaneously at night or while seated quietly for long periods during the day. She felt sleepy during the afternoon, especially while working at her computer. She denied drowsiness while driving. She occasionally took a 30-minute nap on the weekend and found it to be refreshing. She drank one to two cups of coffee every morning and had a 12-oz diet caffeinated soda at 3:00 PM. Her sleepiness had not caused her to make any mistakes at work, and she denied any mood disturbance.

Physical examination was notable for a body mass index of 32 kg/m^2, neck circumference of 38.1 cm (15 in), and modified Mallampati class III oral airway. Nasal passages were narrow with turbinate hypertrophy bilaterally, and hard palate was high-arched and narrow. No micrognathia or retrognathia was present. She had molar occlusion class I bilaterally with no overjet or overbite. The general, cardiac, respiratory, and neurologic examinations were normal.

Comment. This case illustrates how discussion of the chief complaint raises suspicion for multiple sleep disorders. The history suggests a circadian rhythm sleep disorder, particularly delayed sleep-phase syndrome, sleep-disordered breathing, and restless legs syndrome. Diagnostic evaluation should include nocturnal polysomnogram with consideration to perform testing at the patient's preferred sleep time, and serum iron studies. Sleep diaries and/or actigraphy may be considered for further assessment of the patient's sleep pattern.

particular sleep disorders. For patients in whom multiple sleep disorders are suspected, systematic use of diagnostic testing allows for accurate identification of specific diagnoses. In a patient with insomnia and symptoms suggestive of SDB, nocturnal polysomnography should be the first procedure performed. If the insomnia persists despite adequate treatment of SDB, further evaluation with sleep diaries and possibly actigraphy may be considered to better characterize the patient's sleep pattern. Actigraphy may then again be pursued to gauge treatment response upon management of the patient's insomnia.

The diagnostic modalities available for evaluation of sleep disorders are rapidly evolving. In-laboratory nocturnal polysomnography currently remains the gold standard for assessment of SDB. However, the multitude of out-of-center

KEY POINT

- Careful assimilation of the clinical history, the sleep-specific physical examination, patient questionnaires, and diagnostic test results leads to the most accurate assessment of patients with symptoms related to sleep or alertness.

testing devices continues to grow, and many may provide useful alternatives that under appropriate circumstances could allow more expedient, convenient, and less costly evaluations of increased numbers of patients who previously had only limited or delayed access to sleep services.

VIDEO LEGEND

Supplemental Digital Content 2-1

Home sleep study. Video demonstrates a home sleep study using an unattended type 3 portable monitoring device. The patient is a 56-year-old man who is experiencing morning headaches and concentration and alertness problems at work. He has a history of mild snoring and arterial hypertension. His Epworth Sleepiness Scale score is 18, his neck circumference is 19 in, he has a Mallampati classification score of III, and his body mass index is 41 kg/m. The apnea-hypopnea index is 84 events/h. Channels recorded in this sleep study include arterial oxyhemoglobin saturation, heart rate, oral-nasal pressure flow, snoring, inductive plethysmography for chest efforts, and body position.

links.lww.com/CONT/A15

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