Smith Seminars
Online Continuing Education
AARC-Approved for 2 CRCE
Polysomnography and Obstructive Sleep Apnea

Objectives

Understand the importance of polysomnography in diagnosing obstructive sleep apnea.
Know the components of polysomnography and the factors monitored.
Be aware of the adverse effects of obstructive sleep apnea.
Become aware of the possible treatments for obstructive sleep apnea.

Nocturnal, laboratory-based polysomnography (PSG) is the most commonly used test in the diagnosis of obstructive sleep apnea syndrome (OSAS). It is often considered the criterion standard for diagnosing OSAS, determining the severity of the disease, and evaluating various other sleep disorders that can exist with or without OSAS. PSG consists of a simultaneous recording of multiple physiologic parameters related to sleep and wakefulness. PSG can directly monitor and quantify the number of respiratory events, such as obstructive, central, or complex, and the resultant hypoxemia and arousals related to the respiratory events or even independent of the respiratory events.

A single-night PSG is usually adequate to determine if OSAS is present and the degree of the disorder. However, night-to-night variability may exist in patients who have a high probability but a low apnea index. In addition, variability in laboratory equipment, scoring technique, and interscorer reliability may also play roles. As is well known, PSG scoring also usually varies from laboratory to laboratory.

PSG is used to evaluate abnormalities of sleep and/or wakefulness and other physiologic disorders that have an impact on or are related to sleep and/or wakefulness.

Assessment of sleep stages requires 3 studies: electroencephalography (EEG), electrooculography (EOG), and surface electromyography (EMG).

One EEG channel (central channel with an ear reference provides the best amplitude) is used to monitor sleep stage. However, most laboratories use 2 central channels and 2 occipital channels, with ear references as an adjunct to help identify sleep latency and arousals. A 10- to 20-electrode placement system is used to determine the location of these channels. Additional EEG channels can be used, particularly in patients with epilepsy (ie, a full 10-20 montage).

Two EOG channels are used to monitor both horizontal and vertical eye movements. Electrodes are placed at the right and left outer canthi, one above and one below the horizontal eye axis. The electrodes pick up the inherent voltage within the eye; the cornea has a positive charge and the retina has a negative charge. Evaluation of the eye movements is necessary for 2 reasons. First is for documentation of the onset of rapid eye movement (REM) sleep, and second is to note the presence of slow-rolling eye movements that usually accompany the onset of sleep.

One EMG channel (usually chin or mentalis and/or submentalis) is used to record atonia during REM sleep or lack of atonia in patients with REM-related parasomnias. To assess bruxism, the EMG electrodes can be placed over the masseter. The EMG recording from other muscle groups

is assessed for other sleep disorders. For example, the anterior tibialis EMG is helpful for assessing periodic limb movements during sleep and the intercostal EMG is used as adjunctive help for determining effort during respiratory events.

Other parameters that can be monitored in a sleep study include airflow (nasal and/or oral), electrocardiography, pulse oximetry, respiratory effort (thoracic and abdominal), sound recordings to measure snoring, and continuous video monitoring of body positions. Optional parameters that can be monitored in a sleep study include core body temperature, incident light intensity, penile tumescence, and pressure and pH at various esophageal levels.

In 1992, the Office of Technology Assessment of the Agency of Health Care Policy and Research recommended, in an evidence-based assessment, 2 tests as having been studied sufficiently. Both tests are performed in a sleep laboratory. The first is overnight PSG, which is an overnight recording of the patient's sleep. The second is multiple sleep latency testing (MSLT), which records multiple naps throughout a day (usually four 20-min naps separated by 90 min).

Standard sleep studies usually use the overnight PSG (may be performed over several nights). If daytime sleepiness is an issue and cannot be fully explained by the overnight study results, an MSLT should be performed the next day. Limitations usually stem from the fact that recording conditions may not reflect what happens during a regular night in the patient's home.

Although diagnosing a sleep problem on the basis of a recording over a single night is common practice, some authorities caution that more than one night of recording may be necessary so the patient can become comfortable with unfamiliar surroundings and sleep more naturally. This effect is greatest on the first night in the sleep laboratory.

Sporadic events may be missed with a single-night PSG. External factors that disturb the subject's sleep may be present in the home but absent from the controlled environment of the sleep laboratory.

Patient preparation is important so that the patient sleeps naturally. Patient instructions include maintain regular sleep-wake rhythm, avoid sleeping pills, avoid alcohol, avoid stimulants, including medications for narcolepsy and avoid strenuous exercise on the day of the PSG.

Sleep Staging

Electroencephalography (EEG)

Alpha EEG has a frequency of 8-13 cps (cycles per second), produced in occipital region, and crescendo-decrescendo appearance.

Theta EEG has a frequency of 3-7 cps, produced in the central vertex region, no amplitude criteria, and is most common sleep frequency.

Delta EEG has a frequency of 0.5-2 cps, clinical EEG frequency of greater than 0.5-4 cps is seen predominantly in frontal region, and amplitude of greater than 75 mN.

Sleep spindle has a frequency of 12-14 cps, is produced in central-vertex region, greater than 0.5-3 seconds in duration, 0.5-second spindles with 6-7 cycles, and are indicative of stage 2 sleep.

K complexes are sharp, slow waves with a negative, then positive, deflection, no amplitude criteria, with duration must be at least 0.5 seconds, predominantly produced in central-vertex region, is indicative of stage 2 sleep, and may occur with or without stimuli.
Awake stage is greater than 50% of each epoch contains alpha activity, with slow-rolling eye movements or eye blinks seen in EOG channels and has elatively high EMG muscle tone.
Stage 1 sleep is when greater than 50% of the epoch contains theta activity (3-7 cps), alpha activity possible within less than 50% of the epoch, slow-rolling eye movements in EOG channels, and relatively high submental EMG tone.
Stage 2 sleep has theta activity (3-7 cps), K-complexes and sleep spindles occur episodically, and high tonic submental EMG.
Stage 3 sleep accounts for 20-50% of each epoch and must contain delta activity and submental muscle tone may be slightly reduced.
Stage 4 sleep when greater than 50% of the epoch has scorable delta activity and submental EMG activity is slightly reduced from that of light sleep.
REM sleep has rapid eye movements, a mixed frequency EEG (similar to awake pattern), low tonic submental EMG, and may see saw-tooth waves.

Respiratory Events and Leg Movement Scoring

Basic rules include all respiratory events counted are at least 10 seconds in duration, all events need to have at least a 3% or greater oxygen saturation (SaO_2) decrease, and EEG arousals occur with most respiratory events.

Obstructive apnea shows no airflow for greater than 10 seconds, increasing respiratory effort (usually seen as paradoxical), and SaO_2 decrease greater than 3% (may be adjusted).

Hypopnea is a reduction in airflow to approximately 50% of baseline value, SaO_2 decrease of greater than 3%, and usually there is a steadily increasing effort signal, and usually is associated with arousal.

Mixed apnea is a complete absence of nasal and oral airflow, total absence of respiratory effort at the beginning of the event, followed by a gradual increase in effort, which eventually breaks the apnea (usually paradoxical), and SaO_2 decrease of greater than 3%.

Central apnea is the absence of airflow at nose and mouth for greater than 10 seconds, with a complete absence of respiratory effort, and SaO_2 decrease of greater than 3%.

Periodic limb movement involves jerks that must be greater than 0.5 seconds but less than 5 seconds in duration, each jerk must be greater than 0.25 amplitude of physiological calibration, and must have 4 jerks separated by no more than 90 seconds (Some protocols allow for 120-second event variability).

Standard analysis still consists of reviewing each of the parameters recorded. Overnight parameters (times of lights on/off, total time in bed, total sleep time, sleep latency, REM latency) are collected. The overnight recording is divided into epochs of approximately 30 seconds. The

standard EEG, EMG, and EOG recordings are evaluated, and the predominant stage of sleep (according to the manual of Rechtschaffen and Kales) is then assigned to the entire epoch. Total time and relative proportion of the night spent in each of the stages and in REM and non-REM sleep are calculated. Latencies to REM and slow-wave sleep are reported.

Stages of sleep, any abnormalities noted with EEG, and periodic limb movements are reported. Respiratory activity (apneic or hypopneic episodes, oxygen desaturations) is correlated with sleep stages. Other parameters, such as body position, are recorded. If needed, esophageal pH or penile tumescence can also be recorded.

If a sleep apnea syndrome is diagnosed, the patient undergoes a trial and titration of positive airway pressure either (1) in a partial-night PSG titration study if he or she meets criteria based on individual laboratory criteria (generally, apnea-hypopnea index >30) or (2) in a full-night PSG titration study.

Multiple Sleep Latency Test

The Multiple Sleep Latency Test (MSLT) is a validated objective measure of the ability or tendency to fall asleep. The Maintenance of Wakefulness Test (MWT) is a validated objective measure of the ability to stay awake for a defined time. The MWT is used in association with the clinical history to assess the ability to maintain wakefulness. The MWT 40-minute protocol is recommended when the sleep clinician requires objective data to assess an individual's ability to remain awake. To provide a valid assessment of sleepiness or wakefulness, the MSLT and MWT must be performed under appropriate conditions using proper recording techniques and accepted protocols, with interpretation by a qualified and experienced clinician.

The MSLT is indicated as part of the evaluation of patients with suspected narcolepsy to confirm the diagnosis. The MSLT may be indicated as part of the evaluation of patients with suspected idiopathic hypersomnia to help differentiate idiopathic hypersomnia from narcolepsy. The MSLT is not routinely indicated in the initial evaluation and diagnosis of obstructive sleep apnea syndrome or in assessment of change following treatment with CPAP. The MSLT is not routinely indicated for evaluation of sleepiness in medical and neurological disorders (other than narcolepsy), insomnia, or circadian rhythm disorders.

Repeat MSLT testing may be indicated in the following situations:

When the initial test is affected by extraneous circumstances or when appropriate study conditions were not present during initial testing; when ambiguous or uninterpretable findings are present; when the patient is suspected to have narcolepsy but earlier MSLT evaluation(s) did not provide polygraphic confirmation.

The MWT 40-minute protocol may be used to assess an individual's ability to remain awake when his or her inability to remain awake constitutes a public or personal safety issue. The MWT may be indicated in patients with excessive sleepiness to assess response to treatment.

MSLT Protocol

The MSLT consists of five nap opportunities performed at two-hour intervals. The initial nap opportunity begins 1.5 to 3 hours after termination of the nocturnal recording. A shorter four-

nap test may be performed but this test is not reliable for the diagnosis of narcolepsy unless at least two sleep onset rapid eye movement (REM) periods have occurred.

The MSLT must be performed immediately following polysomnography recorded during the individual's major sleep period. The use of MSLT to support a diagnosis of narcolepsy is suspect if total sleep time (TST) on the prior night sleep is less than 6 hours. The test should not be performed after a split-night sleep study (combination of diagnostic and therapeutic studies in a single night).

Sleep logs may be obtained for 1 week prior to the MSLT to assess sleep-wake schedules.

Standardization of test conditions is critical for obtaining valid results. Sleep rooms should be dark and quiet during testing. Room temperature should be set based on the patient's comfort level.

Stimulants, stimulant-like medications, and REM suppressing medications should ideally be stopped 2 weeks before MSLT. Use of the patient's other usual medications (e.g., antihypertensives, insulin, etc.) should be thoughtfully planned by the sleep clinician before MSLT testing so that undesired influences by the stimulating or sedating properties of the medications are minimized. Drug screening may be indicated to ensure that sleepiness on the MSLT is not pharmacologically induced. Drug screening is usually performed on the morning of the MSLT, but its timing and the circumstances of the testing may be modified by the clinician. Smoking should be stopped at least 30 minutes prior to each nap opportunity.

Vigorous physical activity should be avoided during the day and any stimulating activities by the patient should end at least 15 minutes prior to each nap opportunity. The patient must abstain from any caffeinated beverages and avoid unusual exposures to bright sunlight. A light breakfast is recommended at least 1 hour prior to the first trial, and a light lunch is recommended immediately after the termination of the second noon trial.

Sleep technologists who perform MSLTs should be experienced in conducting the test.

The conventional recording montage for the MSLT includes central electroencephalogram (EEG) (C3-A2, C4-A1) and occipital (O1-A2, O2-A1) derivations, left and right eye electrooculograms (EOGs), mental/submental electromyogram (EMG), and electrocardiogram (EKG).

Prior to each nap opportunity, the patient should be asked if they need to go to the bathroom or need other adjustments for comfort. Standard instructions for bio-calibrations (i.e., patient calibrations) prior to each nap include: (1) lie quietly with your eyes open for 30 seconds, (2) close both eyes for 30 seconds, (3) without moving your head, look to the right, then left, then right, then left, right and then left, (4) blink eyes slowly for 5 times, and (5) clench or grit your teeth tightly together. With each nap opportunity the subject should be instructed as follows: "Please lie quietly, assume a comfortable position, keep your eyes closed, and try to fall asleep." The same instructions should be given prior to every test. Immediately after these instructions are given, bedroom lights are turned off, signaling the start of the test. Between naps, the patient should be out of bed and prevented from sleeping. This generally requires continuous observation by a laboratory staff member.

Sleep onset for the clinical MSLT is determined by the time from lights out to the first epoch of any stage of sleep, including stage 1 sleep. Sleep onset is defined as the first epoch of greater than 15 sec of cumulative sleep in a 30-sec epoch. The absence of sleep on a nap opportunity is recorded as a sleep latency of 20 minutes. This latency is included in the calculation of mean sleep latency (MSL). In order to assess for the occurrence of REM sleep, in the clinical MSLT the test continues for 15 minutes from after the first epoch of sleep. The duration of 15 minutes is determined by "clock time," and is not determined by a sleep time of 15 minutes. REM latency is taken as the time of the first epoch of sleep to the beginning of the first epoch of REM sleep regardless of the intervening stages of sleep or wakefulness.
A nap session is terminated after 20 minutes if sleep does not occur.
The MSLT report should include the start and end times of each nap or nap opportunity, latency from lights out to the first epoch of sleep, mean sleep latency (arithmetic mean of all naps or nap opportunities), and number of sleep-onset REM periods (defined as greater than 15 sec of REM sleep in a 30-sec epoch).
Events that represent deviation from standard protocol or conditions should be documented by the sleep technologist for review by the interpreting sleep clinician.

MWT protocol

The 4-trial MWT 40-minute protocol is recommended. The MWT consists of four trials performed at two-hour intervals, with the first trial beginning about 1.5 to 3 hours after the patient's usual wake-up time. This usually equates to a first trial starting at 0900 or 1000 hours.
Performance of a polysomnogram (PSG) prior to MWT should be decided by the clinician based on clinical circumstances.
The room should be maximally insulated from external light. The light source should be positioned slightly behind the subject's head such that it is just out of his/her field of vision, and should deliver an illuminance of 0.10 to 0.13 lux at the corneal level (a 7.5 W night light can be used, placed 1 foot off the floor and 3 feet laterally removed from the subject's head). Room temperature should be set based on the patient's comfort level. The subject should be seated in bed, with the back and head supported by a bedrest (bolster pillow) such that the neck is not uncomfortably flexed or extended.
The use of tobacco, caffeine, and other medications by the patient before and during MWT should be addressed and decided upon by the sleep clinician before MWT. Drug screening may be indicated to ensure that sleepiness/wakefulness on the MWT is not influenced by substances other than medically prescribed drugs. Drug screening is usually performed on the morning of the MWT, but its timing and the circumstances of the testing may be modified by the clinician.
A light breakfast is recommended at least 1 hour prior to the first trial, and a light lunch is recommended immediately after the termination of the secondnoon trial.
Sleep technologists who perform the MWT should be experienced in conducting the test.

The conventional recording montage for the MWT includes central EEG (C3-A2, C4-A1) and occipital (O1-A2, O2-A1) derivations, left and right eye EOGs, mental/submental EMG, and EKG.

Prior to each trial, the patient should be asked if they need to go to the bathroom or need other adjustments for comfort. Standard instructions for bio-calibrations (i.e., patient calibrations) prior to each trial include: (1) sit/lie quietly with your eyes open for 30 seconds, (2) close both eyes for 30 seconds, (3) without moving your head, look to the right, then left, then right, then left, right and then left, (4) blink eyes slowly for 5 times, and (5) clench or grit your teeth tightly together. Instructions to the patient consist of the following: "Please sit still and remain awake for as long as possible. Look directly ahead of you, and do not look directly at the light." Patients are not allowed to use extraordinary measures to stay awake such as slapping the face or singing.

Sleep onset is defined as the first epoch of greater than 15 sec of cumulative sleep in a 30-sec epoch.

Trials are ended after 40 minutes if no sleep occurs, or after unequivocal sleep, defined as three consecutive epochs of stage 1 sleep, or one epoch of any other stage of sleep.

The following data should be recorded: start and stop times for each trial, sleep latency, total sleep time, stages of sleep achieved for each trial, and the mean sleep latency (the arithmetic mean of the four trials). Events that represent deviation from standard protocol or conditions should be documented by the sleep technologist for review by the sleep specialist.

Sleep Disorders

Dyssomnias (disorders of initiating or maintaining sleep)

> Circadian rhythm disorders, narcolepsy, idiopathic hypersomnia, inadequate sleep hygiene, and sleep-related respiratory disorders (sleep apnea syndrome and upper airway resistance syndrome)

Parasomnias

> Disorders of arousal, disorders of sleep-wake transition, disorders that occur during REM sleep (nightmares and REM behavior disorder), medical-psychiatric sleep disorders (sleep-related asthma, depression, panic disorder, sleep-related epilepsy), and other disorders such as bruxism (grinding teeth), restless legs syndrome, and periodic limb movement disorder

Obstructive Sleep Apnea

Obstructive sleep apnea (OSA) is an underdiagnosed debilitating condition that affects approximately 20% of adults in the United States. Characteristics of OSA include snoring and sleep arousal, mood disorders, and increased body mass index (BMI).

The simple definition of obstructive sleep apnea is collapse of the upper airways during sleep, resulting in airflow obstruction and repetitive arousals. Muscle tone maintains upper airway tone, so when we go to sleep our muscles relax and the caliper of our airways will narrow. For some individuals, this narrowing is significant enough to cause turbulent airflow, or snoring. Snoring by itself is not pathologic, but it suggests narrowing of the upper airways. Continued

narrowing results in an obstruction of the upper airways and a cessation of airflow, which is an obstructive apneic event. Apnea is the Greek word meaning "without breath." This obstruction leads to an arousal from sleep which increases muscle tone, reestablishes airway patency, and allows normal airflow. In patients with OSA, there is a repetitive pattern of upper airway collapsibility, airflow obstruction, and resultant arousals. Thus, OSA is defined as repetitive arousals from sleep from collapse of the upper airway. Obstructive sleep apnea syndrome is OSA with more than 5 events per hour that has also some effect on either daytime function or symptoms. The most common symptom is excessive daytime sleepiness. Other consequences of OSA that would then qualify for sleep apnea syndrome include refractory hypertension, depression, and fatigue.

The first landmark study regarding the prevalence of OSA was the Wisconsin Sleep Cohort study, which identified 24% of men and 9% of women who had an apnea-hypopnea index (AHI) of at least 5 events per hour. Limiting the diagnosis to those with both an AHI > 5 and excessive daytime sleepiness, they found that 4% of adult men and 2% of adult women in the United States had OSA syndrome. Since then, several additional large, population-based studies have found the prevalence of OSA to be significantly higher.

Over the last several decades, the prevalence of OSA has been redefined. Based on several large population-based studies, it is currently estimated that at least 1 in 5 American adults has at least mild sleep apnea and 1 in 15 have moderate or severe disease. There are several reasons for this increasing trend. We are an aging population and it has been clearly established that sleep apnea increases with increase in age. In addition, there is a direct link between BMI and the occurrence of sleep apnea. So, as the average BMI continues to increase, we have and will continue to observe a progressive increase in the prevalence of OSA.

Perhaps the greatest reason for the sudden increase in the diagnosis of sleep apnea is an improved awareness by both the medical profession and the lay public. As the awareness of sleep apnea increases, more often it is looked for and therefore it is found more often. There has been a progressive increase in the number of patients diagnosed with sleep apnea over the last decade. In fact, over this time the referrals for sleep studies have increased 12-fold and much of that is the result of increasing awareness.

Unfortunately, the majority of sleep apneics remain undiagnosed. In fact, in the Wisconsin Sleep Cohort Study, it was estimated that 93% of women and 82% of men with moderate to severe OSA are undiagnosed.

Sleep apnea largely is undiagnosed in America and there are several reasons for that. One reason is that there continues to be diagnostic profiling where OSA is only considered in obese, middle-aged men who habitually snore. This clearly is not the case and it creates a risk of missed or delayed diagnoses. Another contributing factor is that there is a narrowed focus on sleep disorders during medical school and residency, which has led to a limited understanding of these conditions among many primary care clinicians. As the field of sleep medicine advances and more patients are diagnosed with OSA and other sleep disorders, primary care clinicians will

need to be able to recognize, diagnose, and treat these conditions. Patients themselves are also contributing to the reduced recognition of OSA. Many may not understand or appreciate their sleep complaints or their consequences and they may not share this information with their clinicians.

Recognizing sleep complaints is often challenging for both patients and clinicians. It is very difficult to qualify or quantify purely subjective symptoms, especially excessive sleepiness. Sleepiness in one individual may be described as fatigue, exhaustion, or depression by another. As such, it is very difficult to determine who may have sleep apnea if you just focus on daytime sleepiness. There are several validated tools to help judge the severity of sleepiness, but they only weakly correlate with patients' actual subjective complaints.

The only way to truly establish the diagnosis of OSA is with polysomnography, or sleep study. The most common is an in-laboratory level 1, attended overnight study. However, recently the Centers for Medicare and Medicaid Services and the American Academy of Sleep Medicine have endorsed the use of portable monitors to establish the diagnosis of sleep apnea in a highly probable low-risk patient population.

Although a polysomnogram is required to establish the diagnosis, there are several predictive tools that can help identify patients with sleep apnea. While they each have their own strengths and limitations, they all basically focus on similar high-risk features, such as habitual snoring, witnessed apneas, an increased BMI, male gender, and advanced age. The risk for OSA increases with increased age, particularly after 50 years old. Obesity and surrogate markers of obesity also increase the probability for OSA. In particular, a BMI greater than 30, a neck circumference greater than 15.5 inches, or truncal obesity are strongly associated with the risk of OSA. Crowding of the oropharynx can also help identify those with OSA. An increased Mallampati score, macroglossia, retrognathia, and micrognathia lead to oropharyngeal crowding, which increases the likelihood of collapsibility of the upper airway and obstruction to airflow during sleep. However, these predictive rules and high-risk features have only modest sensitivity and specificity for OSA. One validated tool which can help identify those with OSA is the STOP BANG questionnaire (Snoring, Tired, Observed apneas, high blood Pressure, BMI > 30 kg/m2, Age > 50, Neck circumference 15.5 inches, male Gender). Simply, the more features a patient has, the greater the pretest probability they have OSA, with sensitivities of 83.6%, 92.9%, and 100% for mild, moderate, and severe sleep apnea, respectively. While useful, it has high false-positive and false-negative rates and, as with all predictive rules, should not replace clinical judgment. When there is a high clinical suspicion for OSA, the patient should be referred for polysomnography to confirm the diagnosis.

In addition to somnolence, increased weight, age, snoring, and witnessed apneas, there are several other prevalent features seen with OSA that are often overlooked. These includesleep fragmentation and poor sleep quality, night sweats, nocturnal reflux, nocturia, progressive weight gain, depression, diminished libido or erectile dysfunction, poor memory or attention, irritability and moodiness, fatigue, and an underlying cardiovascular disease, particularly hypertension.

Sleep medicine specialists are involved in establishing the diagnosis, initiating therapy, and providing follow-up for the majority of patients with OSA. However, as with other common medical conditions, this is a disease that is rapidly transitioning to primary care clinicians. Sleep apnea occurs in one fifth of the adult population and is largely under diagnosed and under treated. As the prevalence of OSA increases, it will quickly overwhelm the clinical sleep medicine community and much of the burden for diagnosing and treating this condition will be the responsibility of primary care clinicians. Family medicine clinicians, internal medicine clinicians, and even pediatricians can make the diagnosis and provide care for patients with OSA. In the future, sleep medicine specialists will likely be utilized to help establish the diagnosis and treat more severe cases or people who have poor adherence with therapy, while the majority of patients will be primarily managed by primary care clinicians.

It is imperative that primary care clinicians become more familiar with sleep apnea. Not only is it a common disorder, but if sleep apnea is overlooked or the diagnosis delayed, it can lead to long-term health consequences and the propagation of sleep apnea. The earlier it is diagnosed the better. Part of the residual hypersomnia that occurs despite adequate therapy is related to the duration of untreated sleep apnea, the severity of the disease, and the severity of nocturnal hypoxia. The longer it takes to diagnose and treat sleep apnea, the less likely it is that the daytime somnolence will resolve. In addition, once established, endothelial dysfunction and metabolic derangements seen with OSA are also less likely to resolve with continuous positive airway pressure (CPAP).

The more understanding there is about sleep apnea, then the more it is realized how it impacts health and quality of life. In regards to quality of life, sleep apnea causes excessive sleepiness, fatigue, and decreased energy. Anything that disrupts sleep quality can lead to excessive sleepiness or fatigue during the day. Irritability, moodiness, and depression are very prevalent in patients with untreated sleep apnea. In a study there was a twofold increased risk of depression in patients with mild OSA and a 2.6-fold increased risk for depression in those with moderate or severe disease.

Not only does OSA impair quality of life, it also adversely affects health, with numerous metabolic and cardiovascular consequences. Metabolic consequences are common in patients with sleep apnea. These occur not only from the disruptive sleep architecture and poor sleep quality, but also from an increased sympathetic tone that results from repetitive arousals. OSA may result in increased insulin levels and cortisol secretion, leading to elevated serum glucose levels and the development of insulin resistance. In addition, there is an imbalance in leptin and ghrelin, hormones which regulate satiety and hunger. This leads to an imbalance in lipogenesis and lipolysis where patients become more efficient at storing fat than utilizing fat, which leads to more weight gain and further propagation of OSA. There are several overlapping risk factors for both OSA and diabetes, such as excessive body weight. However, there is increasing evidence that OSA is independently associated with impaired glucose tolerance, insulin resistance, and the metabolic syndrome.

The repetitive arousals seen in OSA can lead to episodic catecholamine surges and an elevated sympathetic tone. This elevated sympathetic tone with the intermittent hypoxia associated with apneic events can cause endothelial dysfunction with resultant hypertension and accelerated atherosclerosis. Hypertension is extremely common in patients with OSA and occurs in up to 50% of individuals. The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC 7) lists OSA as the most common cause of secondary hypertension in the US. In 2 large case series, OSA was found in 11%-37% of patients with heart failure. There is also an increased risk of myocardial infarctions and cerebrovascular accidents with a clear, dose-response relationship between the severity of sleep apnea and the likelihood of a cardiovascular event.

People with untreated sleep apnea have an increased all-cause mortality rate. In one study of patients with moderate to severe sleep apnea, the 5-year risk of death was 14% in those who refused CPAP versus 4% in those compliant with therapy. Another study found that over a 14-year period, the all-cause mortality associated with moderate to severe sleep apnea was 33% compared with only 7.7% in those without OSA. It could be argued that the same risks for OSA and its associated features, such as older age, male gender, obesity, hypertension, and are the reason for the observed increased risk of cardiovascular events and death. Studies show patients with OSA have significant increased risk factors such as hypertension and diabetes.

Treatment

There are 4 therapies for OSA. One is conservative therapy, which includes weight loss, positional therapy, and treatment of chronic sinus disease, which are all helpful for improving sleep quality and even reducing the severity of OSA. There is a clear association with weight gain and OSA, and the more weight gained, the worse sleep apnea becomes. Weight loss will decrease the severity of sleep apnea, but unfortunately it's not a linear relationship. Patients are unlikely to reduce the severity of sleep apnea proportionate to the amount of weight lost, but all weight loss does help. If the patient has mild sleep apnea, it may be enough to resolve their obstructive events. However, most patients have residual OSA despite weight loss. In a recent study and subsequent meta-analysis, it was found that significant weight loss reduces the severity of OSA, but the majority of individuals had persistent disease.

Between 10% and 30% of patients will have a large positional component of the sleep apnea. Because the pathogenesis of sleep apnea is collapsibility of the upper airway, in the supine position, gravity contributes to the subluxation of the oropharynx and makes upper airway obstruction more likely. Sleeping on one's side or elevating the headboard by 2-4 inches can offload some of the effects of gravity on the upper airway and reduce the severity of sleep apnea. For some people, particularly those with mild OSA, and especially those with a large positional component, forced sleep in the lateral position can be enough to normalize sleep architecture and decrease apneic events.

Sinus congestion actually goes hand in hand with OSA. OSA can cause vasomotor rhinitis. As apneic patients struggle to get air in, the resulting increased upper airway resistance that occurs

can cause inflammation of the upper airways. Sinus congestion in and of itself can cause sleep fragmentation and daytime somnolence. For those with concomitant OSA, it can decrease the efficacy and comfort of CPAP. As such, chronic rhinitis should be treated when present. Conservative therapy should be employed in all patients. However, while they are helpful, they are usually not sufficient to resolve sleep apnea enough to normalize sleep. Three forms of directed therapy are usually recommended for all patients with sleep apnea syndrome: CPAP, oral appliances, and surgery.

Oral appliances are either fixed or titratable devices that advance the mandible to prevent subluxation of the tongue and oropharyngeal collapse. These devices can be very effective in certain patients. They are usually better for those with mild and potentially moderate sleep apnea, and there is some success in people with severe disease. When they are effective, they represent a very good treatment option for people with sleep apnea. They are limited by temporomandibular joint discomfort and malocclusion of the teeth, especially over time.

Surgery can be an effective treatment for sleep apnea. There are different surgical techniques. Some of those are better for snoring than they are for sleep apnea, such as the uvulopalatopharyngoplasty. In correctly selected patients, approximately 50% of people will have a 50% reduction in the apnea-hypopnea index. However, patients with moderate to severe sleep apnea are often left with residual disease despite what is considered to be a successful surgery. Some other surgical techniques such as genioglossus advancement or maxillomandibular osteotomy can be very effective, especially if performed as staged procedures. However, any surgical procedure is associated with inherent risks and the possibility that it will not resolve OSA and should only be performed in properly selected patients. Typically, surgery should be reserved for patients who are intolerant of CPAP.

CPAP is the most effective and most widely used treatment for OSA, and approximately 95% of people will have a 90%-95% reduction in their apnea hypopnea index. For the vast majority of people, this provides adequate therapy. CPAP delivers a column of air that acts as a pneumatic splint to hold open the upper airways and prevent collapsibility and closure. While extremely effective, CPAP does not offer a cure, but merely a treatment. Therefore, if the patient does not use the CPAP, they have untreated sleep apnea. Although effective, adherence with therapy remains problematic. Patients often struggle with compliance because CPAP requires an interface with a mask that pushes a column of air into the upper airway passage. This can be uncomfortable for patients, especially in the initial treatment period where they are learning to adjust and sleep with their CPAP. Often we see this negative conditioning response where people will initially be intolerant of CPAP. Unfortunately, this initial discomfort may lead to an abandonment of therapy, and most people who discontinue CPAP will do so within the first month. In fact, long-term compliance is often predicted very early in the course of therapy, often within the first few weeks or perhaps even in the first few days of CPAP use. Those who adapt to the CPAP quickly will often continue to use it long-term, and those who struggle initially will often abandon therapy. About 50% of people who start CPAP will not be using it one year later. Despite being a very effective and cost-effective treatment for sleep apnea, adherence to CPAP

therapy remains problematic. Interventions that improve the initial experience with CPAP have been shown to improve long-term use, such as better mask fitting, comprehensive patient education, and a short course of sedative-hypnotics during the initial treatment period.
A few agents have been studied, but none have been shown to be very effective. One of the problems with sleep apnea is the sleep fragmentation and the repetitive arousals from sleep. Sedative-hypnotics can decrease some of the arousals and sleep fragmentation that occurs with sleep apnea. Of course they do not prevent airway closures or stop the apneic event, so patients will still have sleep apnea. While this doesn't fix the primary problem of sleep apnea, it may provide some better sleep continuity and some decrease in sleepiness during the day. Of course these medications should not be used as the sole treatment for sleep apnea because they do not resolve the underlying pathophysiologic cause or consequence of sleep apnea.
We know that sleep apnea is not the same throughout the course of the night. It tends to be worse in certain stages of sleep, especially in rapid-eye-movement (REM) sleep. REM sleep induces skeletal muscle atonia, making the upper airways more susceptible to collapse. Agents that suppress REM sleep, such as tricyclic antidepressants, selective serotonin reuptake inhibitors, and serotonin-norepinephrine reuptake inhibitors can reduce the severity of sleep apnea. Again, these agents do not resolve sleep apnea completely, and over time they have less effect on REM suppression. Also, these medications are associated with sleep fragmentation and may cause excessive daytime sleepiness. Therefore, they do not provide an effective long-term solution. They may be a reasonable alternative in patients as either an adjunctive therapy to CPAP or in patients with very mild and REM-specific sleep apnea.
Non-amphetamine based stimulants, including modafinil (Provigil) or armodafinil (Nuvigil) are approved by the US Food and Drug Administration as adjunctive therapy to CPAP in patients with residual daytime sleepiness despite adequate therapy. CPAP is the most effective therapy sleep apnea, a third of patients will have residual subjective sleepiness and up to two thirds of patients have residual objective sleepiness despite good adherence with CPAP therapy. OSA, particularly moderate to severe disease associated with significant nocturnal hypoxia, can cause neurocognitive dysfunction that may be irreversible and lead to persistent somnolence despite adequate therapy. For patients who have persistent hypersomnia despite adequate CPAP therapy, both modafinil and armodafinil have been shown to be extremely effective in improving quality of life and daytime function and reducing both objective and subjective sleepiness. However, they should not be used as the primary treatment, but reserved for those who have residual somnolence despite adherence with CPAP.
There is a clear association with sleep apnea and BMI. Excessive weight can cause or precipitate OSA and OSA can lead to weight gain. In short, there is a vicious cycle between OSA and weight gain. Weight gain tends to cause a deposition of fat in the upper airways, which narrows oropharyngeal patency. The more weight you gain, the worse your sleep apnea becomes. The prevalence of OSA is at least 90% in morbidly obese individuals. Not only is OSA more prevalent, but disease severity is usually worse and the oxygen nadir at night is much lower.

Like all causes of poor sleep or sleep deprivation, OSA by itself promotes weight gain. Sleep disorders create an imbalance of leptin and ghrelin and tend to elevate cortisol levels, which helps to promote more weight gain. It is not necessarily a function of caloric intake and exercise, but rather hormone-mediated weight gain that leads to this cycle seen in OSA. Since weight gain causes or worsens sleep apnea, it would make sense that weight loss would reduce the severity of sleep apnea, and it clearly does. The problem is that except for mild sleep apnea, patients are unlikely to resolve OSA with weight loss. And patients with untreated sleep apnea may have difficulty losing weight because of the hormonal imbalance. Even significant weight loss, especially in those with moderate to severe disease, may not resolve OSA completely. A recent meta-analysis assessing the effect of bariatric surgery on OSA concluded that the majority of patients with OSA had persistent disease despite very significant weight loss. Weight loss offers numerous benefits to both health and quality of life and should be encouraged in all patients, especially those with OSA, as it will also reduce disease severity. However, patients should not assume that even significant weight loss has resolved their apneic events. Doing so creates a risk of unrecognized and untreated disease that can result in a re-accumulation of weight as well as the other adverse effects on health and quality of life.

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