Nocturnal Seizures

Carl W. Bazil, M.D., Ph.D.[1]

ABSTRACT

As a subset of epilepsy, nocturnal seizures amplify one of the major problems of epilepsy in general: episodes are less likely to be directly witnessed than daytime seizures, and therefore diagnosis and characterization are more difficult. As a sleep problem, nocturnal seizures are not benign, and the resulting sleep disruption can cause daytime somnolence and concentration difficulty. This article outlines three major topics in nocturnal seizures: differential diagnosis (distinguishing between seizures and parasomnias), the effects of nocturnal seizures on sleep structure, and specific syndromes of primarily or exclusively nocturnal seizures.

KEYWORDS: Sleep, seizure, epilepsy, juvenile myoclonic epilepsy, frontal lobe, benign Rolandic epilepsy, polysomnography

Objectives: On completion of this article, the reader should be able to make a distinction between nocturnal seizures and other normal and abnormal sleep phenomena.

Accreditation: The Indiana University School of Medicine is accredited by the Accreditation Council for Continuing Medical Education to provide continuing medical education for physicians.

Credit: The Indiana University School of Medicine designates this educational activity for a maximum of 1 Category 1 credit toward the AMA Physicians Recognition Award. Each physician should claim only those hours of credit that he/she actually spent in the educational activity.

Disclosure: Statement has been obtained regarding the author's relationships with financial supporters of this activity, use of trade names, investigational products, and unlabeled uses that are discussed in the article. The author has nothing to disclose.

Sleep and epilepsy have a complicated interrelationship that is discussed more fully in another section of the review of sleep and epilepsy. Within this area, nocturnal seizures are a distinct subset of epilepsy. Three aspects of this topic are of primary importance to clinicians. First, nocturnal seizures are rarely witnessed, and therefore a complete description is often lacking. This can cause confusion with other paroxysmal events, primarily parasomnias. Second, nocturnal seizures profoundly disrupt sleep structure, with consequent effects on daytime functioning of patients. Finally, there are many syndromes where the restriction of seizures primarily or exclusively to sleep has important ramifications for diagnosis, treatment, or both.

DIFFERENTIAL DIAGNOSIS OF NOCTURNAL SEIZURES

There are a large number of normal and abnormal sleep phenomena that can be confused with seizures. These phenomena almost always occur at night, so that the beginning of even dramatic episodes is unwitnessed, and patients frequently have little or no recall of the events. Three general classes of events will be discussed: normal

Introduction to Sleep and Its Disorders; Editor in Chief, Karen L. Roos, M.D.; Guest Editor, Alon Y. Avidan, M.D., M.P.H. *Seminars in Neurology*, Volume 24, Number 3, 2004. Address for correspondence and reprint requests: Carl W. Bazil, M.D., Ph.D., Columbia Comprehensive Epilepsy Center, 710 West 168th Street, New York, NY 10032. [1]Columbia Comprehensive Epilepsy Center, New York, New York. 0271-8235,p;2004,24,03, 293,300,ftx,en;sin00322x.

Table 1 Characteristics of Specific non-REM Sleep Disorders and Seizures

	Seizure	Sleep Drunkenness	Sleep Terrors	Somnambulism	Somniloquy	Sleep Enuresis	PLMS, RLS
Incontinence	+	−	−	−	−	+	−
Tongue biting	+	−	−	−	−	−	−
Confusion	+	+	+	+	+	−	−
Tonic-clonic movements	+	−	−	−	−	−	−
Drooling	+	−	−	−	−	−	−
Amnesia	+	+	−	+	+	−	−
Occur while awake	+	−	−	−	−	−	+

PLMS, periodic limb movements of sleep; RLS, restless legs syndrome.

sleep phenomena, insomnias (including sleep apnea), and parasomnias. The latter are divided into those that are more commonly associated with non–rapid eye movement (REM) and REM sleep (Tables 1 and 2).

Normal Sleep Phenomena

Most aspects of normal sleep are easily distinguished from epilepsy. "Sleep starts" occur in nearly all people at one time or another, and consist of a sudden, typically synchronous extension of one or more limbs and sometimes the trunk. They occur while falling asleep and are occasionally associated with a brief dream image, such as that of falling. Sleep starts can be exacerbated by sleep deprivation or by excessive use of stimulant medications, including caffeine. Only rarely would these be confused with seizures, perhaps when they are unusually violent or frequent.

"Sleep drunkenness" consists of prolonged confusion when awakening, usually from the deeper non-REM stages of sleep. There can be complex behaviors without conscious awareness.[1] Patients (typically children) may arise from bed, stumble while walking, have slurred or incomprehensible speech, and have no memory of the event. The occurrence of sleep drunkenness is increased by factors that deepen sleep (such as sleep deprivation and hypnotic medication) or disturb sleep (as in sleep apnea).[2] Potential confusion with seizures occurs because the awakening may be unwitnessed and the subsequent, transient confusion is consistent with a complex partial seizure or postictal state.

Insomnia and Idiopathic Daytime Somnolence

Insomnia and excessive daytime sleepiness are extremely common phenomena. According to a survey by the National Sleep Foundation in 2001, 7% of Americans have drowsiness sufficient to interfere with normal activities on a daily basis, and another 14% experience this at least several times a week.[3] Drowsiness can have serious health consequences as well; 1% of respondents in this same poll reported having automobile accidents because of falling asleep while driving. Sleep disorders are often not reported to physicians and are typically not a part of a routine evaluation.

The symptoms of sleepiness are not often confused with epilepsy. They are, however, so pervasive that some unusual presentations can be confused with seizures. Rare patients report that they have lost a period of time, or suddenly find themselves in bed or on a sofa not knowing how they have gotten there. If the events are unwitnessed it may be impossible to distinguish an epileptic seizure from a so-called "sleep attack," except through video-electroencephalographic (EEG) monitoring.

Table 2 Characteristics of Specific REM Sleep Disorders and Seizures

	Seizure	Nightmare	Cataplexy	Sleep Paralysis	Hypnic Hallucinations	REM Behavior Disorder
Incontinence	+	−	−	−	−	−
Tongue biting	+	−	−	−	−	−
Confusion	+	−	−	−	−	−
Tonic-clonic movements	+	−	−	−	−	−
Drooling	+	−	−	−	−	−
Amnesia	+	−	−	−	−	−
Occur while awake	+	−	+	+	+	−

Sleep Apnea

Obstructive sleep apnea is arguably the most important sleep disorder in terms of morbidity and mortality. Prevalence varies widely depending on sampling technique and definition but is probably at least 3%.[4] Obstructive sleep apnea is characterized by repetitive episodes of complete or partial airway obstruction and is accompanied by symptoms of either excessive daytime sleepiness or insomnia. The usual symptoms of sleep apnea are not easily confused with epilepsy. Severe hypersomnolence, however, can result in sleep attacks with apparent sudden loss of consciousness. In some individuals, sleep apnea can provoke epileptic seizures or be the primary reason for intractability of epilepsy.[5,6] In these cases, seizures are probably triggered by hypoxia during apneic episodes, possibly associated with cardiac dysrhythmias, and seizures will be primarily or exclusively nocturnal. Obstructive sleep apnea is particularly important as it is frequently overlooked in epilepsy patients, and appropriate treatment can result in resolution of seizures.

Disorders Predominantly Associated with non-REM Sleep

SLEEP TERRORS

Sleep terrors (also referred to as pavor nocturnus or incubus attacks) predominantly occur in children. They usually resolve by adolescence; in adults they can be a manifestation of psychopathology such as severe emotional stress[7] or can be triggered by medication (sedative-hypnotics, stimulants, neuroleptics), alcohol, or sleep deprivation. Typically, the patient will suddenly sit up and scream. He or she will be inconsolable and may be very confused. A parent or onlooker who hears the cry and finds the patient confused may then give a history compatible with a nocturnal seizure. The patient is usually amnestic for the episode, adding to potential confusion with seizures. Episodes can be precipitated by agents that increase deeper non-REM sleep and by sleep deprivation. Sleep terrors can usually be distinguished from seizures by their exclusive occurrence in sleep combined with the characteristic dream imagery, predominant fear, and rapid recovery. Abnormal movements, prolonged confusion, drooling, and tongue biting are suspicious for seizure.

SOMNAMBULISM, SOMNILOQUY, AND SLEEP ENURESIS

Sleepwalking (somnambulism), somniloquy (sleep talking), and sleep enuresis (bed-wetting) are also very common in childhood and rare in adults. Somnambulism consists of leaving the bed and performing complex activities, such as walking, without memory for the event. It begins during slow wave sleep and is of various duration and complexity. Sometimes the patient can be agitated during the episode. The prevalence in children is between 1 and 17%, with the peak incidence at age 12. In adults the prevalence is lower but somnambulism remains relatively common (up to 2.5%).[8,9]

Somniloquy can occur in non-REM or REM sleep. It is very common (particularly in children), benign, and should be easily distinguished from nocturnal seizures. Unlike seizures, speech during somniloquy is random (although may be slurred and nonsensical); ictal speech tends to be stereotyped in a given individual. With somniloquy there should be no abnormal movements, drooling, tongue biting, or incontinence. No treatment is required.

Sleep enuresis can occur in non-REM or REM sleep, although the former is probably more common. The cause remains unknown although genetic, behavioral, and psychological factors have been suggested.[10] As these episodes are typically unwitnessed, atypical characteristics suggestive of seizure, including nocturnal injury, tongue or lip biting, or morning muscle soreness, warrant neurological evaluation and probably video-EEG monitoring to rule out unrecognized seizures.

PERIODIC LIMB MOVEMENTS AND RESTLESS LEGS SYNDROME

Periodic limb movements and restless legs syndrome are both relatively common conditions. The incidence of restless legs syndrome is between 2.5 and 15%.[11,12] Periodic limb movements occur in ~5% of young adults; however, the prevalence may be as high as 44% in patients over age 64.[13–16] They often occur together and have many characteristics in common, thus are discussed together.

Periodic limb movements consist of repetitive cycles of rhythmic movement, usually occurring in one or both legs but sometimes involving the arms. Patients are unaware of the movements but may report frequent awakenings. The history from a bed partner may be of jerking movements in sleep, therefore potentially resulting in confusion with epilepsy. On closer questioning, however, the movements are not clonic, are typically limited to a single limb, and occur many times during the night at regular intervals. Most commonly, they occur in clusters every 5 to 90 seconds with each movement lasting 0.5 to 5 seconds.[17]

Restless legs syndrome is usually characterized by an itching or burning sensation in the legs that occurs when the patient is relaxed, particularly when trying to go to sleep. This is followed by movement of the legs with relief of the sensation. The movement can be suppressed voluntarily; however, typically the urge to move becomes overwhelming. Many patients need to actually walk to stop the sensation. As opposed to periodic limb movements, restless legs syndrome becomes manifest during wakefulness or drowsiness as opposed to sleep. Similar to periodic limb movements,

however, a description of irresistible shaking of the legs could be confused with epilepsy; a major difference is that restless legs syndrome can be suppressed voluntarily while an epileptic seizure cannot be suppressed.

Disorders Predominantly Associated with REM Sleep

NIGHTMARES

Nightmares consist of frightening dreams that often awaken the patient from sleep and can be accompanied by agitation. Unlike non-REM phenomena like sleep terrors, there is usually no limb thrashing or ambulation. A history usually identifies these as benign events; however, if specific dream imagery is not recalled, a history of sudden fear followed by confusion might be mistaken for nocturnal seizures.

NARCOLEPSY AND ISOLATED HYPNIC HALLUCINATIONS, SLEEP PARALYSIS, AND CATAPLEXY

Narcolepsy is a complex disorder in which various sleep phenomena associated with REM sleep invade normal wakefulness. It is defined as a clinical tetrad that includes excessive daytime sleepiness, cataplexy, hypnagogic hallucinations, and sleep paralysis. Only 10 to 15% of patients, however, experience all symptoms.[18] All have excessive daytime somnolence, and associated cataplexy occurs in ~70%, hypnagogic hallucinations in 30%, and sleep paralysis in 25%. The individual symptoms can all be confused with epilepsy, including somnolence that can result in sleep attacks. All can also occur as isolated symptoms, without a diagnosis of narcolepsy. Narcolepsy is a relatively unusual disorder; incidence is ~0.05% in Caucasians but may be higher in other populations.[19] Excessive daytime sleepiness is required for the diagnosis of narcolepsy; however, this symptom is unlikely to be mistaken for epilepsy, although some patients report an irresistible sleepiness culminating in a "sleep attack" where sleep onset can occur while talking, driving, or walking. Cataplexy is generally more disturbing to the patient and can be mistaken for epilepsy. These episodes consist of sudden loss of muscle tone (most commonly in the face or knees) with preserved consciousness. This can result in falling and paralysis but more often is limited to buckling of the knees or slurring of speech. Brief twitching of facial or limb muscles can occur and, when rhythmic, add to potential confusion with epilepsy. Cataplectic attacks classically occur in the setting of strong emotion, most commonly laughter[20,21] but also anger, fear, surprise, or excitement.[19] The association with external emotion can aid in the distinction from epileptic seizures.

Sleep paralysis consists of the inability to move or speak with onset during the process of falling asleep (or, less commonly, upon awakening). It typically lasts less than 10 minutes, although it can persist for up to half an hour. Hypnogogic (or hypnopompic) hallucinations also occur while falling asleep (or waking up). The content can be simple (a brief image of a face) or complex (an entire scene occurring in the room) and is usually visual although auditory, somatosensory, vestibular, and olfactory hallucinations also can occur. The sensation is incorporated into the waking background, and the patient is fully aware during the episode.

Cataplexy, hypnagogic hallucinations, and sleep paralysis can occur in the absence of narcolepsy, and in these cases are more likely to be mistaken for epilepsy. Episodes of cataplexy are reported in up to 29% of young adults.[22,23] Sleep paralysis is quite common, occurring in up to 60% of normal subjects,[19–24] although the prevalence of repetitive episodes is probably ~5%.[25] Hypnogogic and hypnopompic hallucinations occur in up to 19% of normal subjects[26]; these are also unlikely to be repetitive when benign. Sleep deprivation may increase the likelihood of these phenomena.

REM BEHAVIOR DISORDER

REM behavior disorder was described relatively recently, in the 1980s.[27,28] It is characterized by agitated, sometimes violent movements occurring during REM sleep. Kicking, punching, jumping, and running from the bed are commonly seen. Injury is also common and can occur to either the patient or the bed partner. Patients will typically report that a dream sequence occurs during the episode. Most patients are male, and the majority are over age 60 years.[29,30] About half of patients have known neurological disorders, most commonly Parkinson's disease, dementia, or multisystem atrophy.[29,31] Physiologically, the disorder consists of absence of normal atonia and increased phasic and tonic electromyogram activity during REM sleep; these can be documented on routine polysomnography with chin and axial electromyography.

The history of bizarre, semipurposeful behavior with confusion may be impossible to distinguish from seizures or postictal behavior. Unlike most partial seizures, REM behavior disorder will be restricted to sleep and usually occur in the early morning when REM is most prevalent. The memory of a dream sequence, if present, is helpful in distinguishing the two. If in question, diagnosis is readily made with video-EEG monitoring, ideally with simultaneous examination of polysomnographic parameters.

Approach to the Differential Diagnosis of Sleep Disorders and Epilepsy

As with nearly all cases involving epilepsy, a careful history is by far the most important part of making a diagnosis. Both seizures and parasomnias can be paroxysmal, and in many cases have similar clinical semiology (Tables 1 and 2). Those most commonly confused with

epilepsy are cataplexy, sleep attacks (especially related to narcolepsy), night terrors, and REM behavior disorder. Episodes that occur only during sleep should raise the suspicion of a sleep disorder, although cataplexy and sleep attacks occur with the patient awake. Additionally, many patients with sleep disorders have excessive daytime somnolence, and daytime attacks can occur during naps. Conversely, there are many epilepsy syndromes where attacks occur predominantly or exclusively during sleep (such as benign Rolandic and nocturnal frontal lobe epilepsies, discussed below). Excessive daytime somnolence is suggestive of an underlying sleep disorder, particularly narcolepsy but also restless legs syndrome, sleep apnea, and periodic limb movements. This can be helpful in diagnosis; however, frequent nocturnal seizures will also disrupt sleep and result in similar symptoms.

SEIZURES AND SLEEP

Effects of Nocturnal Seizures on Sleep

Intuitively, any nocturnal seizure has the potential to disrupt sleep structure. Most will cause at least a brief awakening, and normal sleep is unlikely during a postictal state. It may seem that such disruption could be relatively minor, but actually even brief seizures can result in prolonged alterations in sleep structure. Many studies have shown improvement in sleep with treatment of nocturnal seizures.[32–34] In particular, most have shown improvement in sleep efficiency, decreased arousals, and increases in REM sleep, although it is sometimes difficult to distinguish effects of anticonvulsants from effects of seizures. Importantly, patients with partial seizures have been shown to have relatively normal sleep on seizure-free nights except for slightly decreased sleep efficiency with temporal lobe epilepsy.[35]

The effects of individual temporal lobe seizures were determined through an investigation of patients in an epilepsy monitoring unit who were recorded with polysomnography under baseline conditions (seizure-free) and following complex partial or secondarily generalized seizures.[36] With daytime seizures, there was a significant decrease in REM the following night (12% versus 18% for baseline) without significant changes in other sleep stages or in sleep efficiency. When seizures occurred at night, this decrease in REM was more pronounced (7% versus 16%) and there were increases in stage 1 and decreases in sleep efficiency. These effects were even more pronounced when seizures occurred early in the night. Similar results have been found by other investigators, particularly for generalized seizures.[37]

Therefore, seizures can have a profound effect on sleep, lasting much longer than the apparent postictal period. This helps to explain a commonly seen clinical phenomenon: patients who have only nocturnal seizures report difficulty concentrating or even total inability to work on the days following a seizure.

Effect of Sleep, Sleep Deprivation, and Sleep Disruption on the Occurrence of Seizures

The amount of baseline rhythmicity occurring in the brain differs considerably between the states of sleep and wakefulness. It is therefore not surprising that various seizure types begin preferentially in sleep as opposed to wakefulness or in specific stages of sleep. Crespel and colleagues[35] examined the occurrence of frontal and temporal lobe seizures in 30 patients, using 5 days of continuous video-EEG monitoring. Sixty-one percent of frontal seizures began during sleep compared with only 11% of temporal lobe seizures. In a larger study, Bazil and colleagues[38] retrospectively studied over a thousand seizures in 188 consecutive patients to look at patterns of onset in relationship to sleep. A similar prospective study was performed later and restricted to patients with partial seizures.[39] Both of these studies showed that, overall, 20% of seizures occurred during sleep. Frontal lobe seizures began during sleep more often than temporal lobe seizures, a finding that has been appreciated clinically. Both studies also showed that temporal lobe seizures were more likely to secondarily generalize when beginning during sleep but frontal lobe seizures were not. This intriguing finding suggests differences in the pathways of spread in partial epilepsy, which could have implications for treatment if better understood. Seizures that occur only during sleep may represent an important, distinct class as these have a particularly good prognosis.[40,41]

One of the most interesting and robust findings across many studies is the relative protection of REM against the occurrence of focal seizures. Several studies in epilepsy patients suggest that seizures are rare during REM. In one study mentioned above,[39] an analysis of 613 seizures in 133 patients showed that seizures begin commonly during the lighter stages of non-REM sleep but are rare during slow-wave sleep and none beginning during REM were recorded (Fig. 1). It is not clear how the REM state could inhibit the occurrence of seizures. Electrophysiologically, cerebral activity during REM most closely resembles wakefulness or light sleep; however, the above studies show that seizures occur less frequently during REM than either of these states. It may be that relative hypersynchrony present during non-REM sleep may facilitate the onset and/or spread of certain partial seizures. This is an important area for future research, as understanding the mechanism whereby REM sleep inhibits seizure onset and propagation could lead to novel treatments for intractable epilepsy.

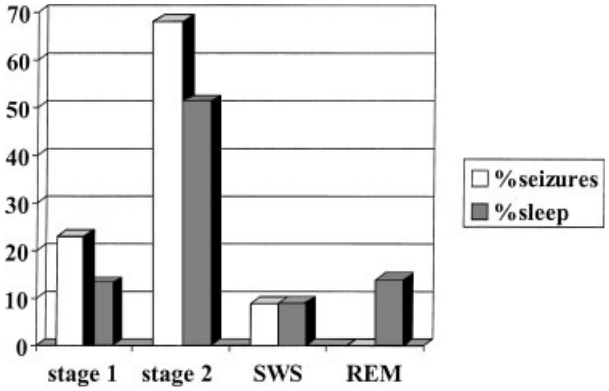

Figure 1 Onset of partial seizures in relation to sleep stage. Sleep stage of onset in 613 partial seizures. Percentage of seizures is the percent of total sleep onset seizures arising in each sleep stage. Percentage of sleep is the breakdown of each stage as a percentage of total sleep in a subset of patients who had polysomnography. (Adapted from Herman et al, 2001.)

Sleep deprivation has long been thought to increase the risk of seizures, which is clinically readily apparent in a few syndromes such as juvenile myoclonic epilepsy. However, a controlled study of patients with refractory partial epilepsy failed to show an effect of sleep deprivation.[42] Seventeen patients were sleep deprived on alternate nights, and 13 received 8 hours of sleep per night. There was no difference in the number of seizures or time to first seizure. This brings into question the common practice of sleep deprivation in epilepsy monitoring units. Sleep deprivation probably does increase the risk of seizures in most patients in the outpatient setting, particularly when chronic. This can be due to sleep disorders (as described above) or from outside influences like poor sleep hygiene, or can be voluntary: patients simply restrict themselves to an inadequate sleep time because of time constraints on other aspects of their lives. Any of these influences can result in increased seizures, further disrupting the already limited sleep time. A cycle of sleep disruption and intractable epilepsy can result, and seizures will not be controlled until the sleep disruption is also resolved.

Finally, certain circadian rhythms may influence seizures independently of sleep. An experimental model with rats with limbic epilepsy and humans with medial temporal seizures have increased seizures during daylight, an effect not seen with human extratemporal seizures.[43] This is likely independent of sleep, of course, because rats are primarily nocturnal and humans diurnal. Humans with intractable temporal lobe epilepsy show abnormal secretion of melatonin, a sleep-related hormone with a characteristic circadian pattern.[44] Exogenous melatonin has been shown to help control seizures in a few small studies,[45,46] raising the possibility that it may be useful in the treatment of some patients.

Syndromes of Nocturnal Seizures

Although most seizure types have the potential to occur during sleep, some have a particularly strong association. These include juvenile myoclonic and awakening grand mal, benign Rolandic, electrical status epilepticus of sleep, and the Landau-Kleffner syndrome (LKS). Certain partial seizures also have a relationship to sleep, particularly frontal onset seizures.

Awakening grand mal epilepsy and juvenile myoclonic epilepsy are often considered together with respect to sleep. Both potentially include multiple seizure types (absence, myoclonic, and generalized tonic-clonic). In both, seizures tend to occur in early morning hours shortly after awakening, although some patients have a second peak of occurrence in the early evening.[47] Myoclonic seizures can be subtle and overlooked for years as simple clumsiness but can be considerably debilitating. Patients may be exceedingly sensitive to sleep deprivation and alcohol consumption, with seizures sometimes virtually inevitable under these conditions. In a few cases strict adherence to sleep hygiene can virtually eliminate the occurrence of seizures. Most patients are fully controlled on medication, but the condition tends to persist throughout life and treatment must be continued even after the patient has been seizure free for many years.[47,48]

Benign Rolandic epilepsy, also known as benign epilepsy with centrotemporal spikes, is a syndrome that typically begins in childhood and invariably remits in adolescence. It is characterized by seizures consisting of unilateral clonic jerking, often involving the face, and hypersalivation. Patients are often fully awake during the seizures. Seizures are predominantly nocturnal in all cases and exclusively begin during sleep in about half.[49,50] The EEG shows characteristic spikes maximal in the central and temporal regions bilaterally and increasing dramatically during non-REM sleep.

LKS is a condition of acquired aphasia, frequently (but not always) with epileptic seizures and a markedly epileptiform EEG, particularly in sleep. Seizures are seen in $\sim$70% of patients but are typically easily controlled with medication.[51] O'Regan and colleagues[52] studied 25 children with an acquired disorder of communication and seizures but not strictly meeting criteria for the LKS. EEGs were uniformly epileptiform and usually (16/25) worsening with sleep. Most were considered to have a receptive aphasia. Language deficits have been hypothesized to result from the persistent epileptic discharges, as evidenced by hypometabolism on single-photon emission-computed tomography.[52]

Electrical status epilepticus during sleep is similar to LKS in age of onset and EEG findings. Both conditions demonstrate a normal EEG background during wakefulness, with generalized spike-wave discharges or sometimes focal epileptiform activity. However, in electrical status epilepticus during sleep, discharges during

sleep are generalized while in LKS activity is more temporally located. In electrical status epilepticus during sleep, epileptiform activity becomes virtually continuous during non-REM sleep such that is may be impossible to distinguish sleep stages. REM sleep remains relatively preserved.[53]

Partial seizures tend to occur in both sleep and wakefulness, although the relative distribution varies according to site of onset. Clinically, an influence of sleep is widely accepted for frontal onset partial seizures. Three studies in patients with epilepsy support that frontal lobe seizures have been shown to occur more frequently during sleep compared with temporal lobe seizures.[35,38,39] In a review of 100 consecutive cases of nocturnal frontal lobe epilepsy,[54] 28% occurred in stage 3 to stage 4 sleep and only 3% during REM. Clear epileptiform abnormalities on routine EEG occurred in less than half of patients. Forty-two patients showed a clear ictal discharge on polysomnography. Autosomal-dominant nocturnal frontal lobe epilepsy, a specific subtype of frontal lobe epilepsy, is characterized by enuresis, sudden awakenings with dystonic or dyskinetic movements, complex behavior, and violent behavior in sleep.[55] Most patients showed ictal or rhythmic activity over the frontal region. Autosomal-dominant inheritance with reduced penetrance is seen. As discussed in the section on the effects of sleep on seizures, sleep can also affect the likelihood of secondary generalization in certain subtypes of partial seizures.

CONCLUSIONS

Nocturnal seizures are an important subset of epilepsy. When seizures continue to occur, even if only during sleep, they can still result in morbidity due to disruption of normal sleep structure. Occurrence of seizures in relation to the sleep-wake cycle has important diagnostic implications in several syndromes. Perhaps more importantly, understanding of the regulatory aspects certain sleep stages have on sleep could help the understanding of the factors influencing seizure onset and, thereby, direct novel treatments for epilepsy.

REFERENCES

1. Guilleminault C, Montplaisir J, Billiard M, Dement WC. Automatic behavior syndrome in patients with excessive daytime somnolence. Electroencephalogr Clin Neurophysiol 1975;39:432–433
2. Broughton RJ. Behavioral parasomnias. In: Chokroverty S, Daroff RB, eds. Sleep Disorders Medicine Boston: Butterworth Heinemann; 1999:635–660
3. National Sleep Foundation. 2001 Sleep in America Poll. Washington, DC: National Sleep Foundation; 2001
4. Chervin RD, Guilleminault C. Obstructive sleep apnea and related disorders. Neurol Clin 1996;14:583–609
5. Malow BA, Levy K, Maturen K, Bowes R. Obstructive sleep apnea is common in medically refractory epilepsy patients. Neurology 2000;55:1002–1007
6. Devinsky O, Ehrenberg B, Barthlen GM, Abramson HS, Luciano D. Epilepsy and sleep apnea syndrome. Neurology 1994;44:2060–2064
7. Kales A, Soldatos CR, Caldwell AB, et al. Somnambulism: clinical characteristics and personality patterns. Arch Gen Psychiatry 1980;37:1406–1410
8. Bixler EO, Kales A, Soldatos CR, Kales JD, Healey S. Prevalence of sleep disorders in the Los Angeles metropolitan area. Am J Psychiatry 1979;136:1257–1262
9. Klackenberg G. Somnambulism in childhood—prevalence, course and behavioral correlates: a prospective longitudinal study (6–16 years). Acta Paediatr Scand 1982;71:495–499
10. Mahowald MW, Schenck CH. NREM sleep parasomnias. Neurol Clin 1996;14:675–696
11. Strang RR. The symptoms of RLS. Med J Aust 1967;1:1211–1213
12. Lavigne GJ, Montplaisir JY. Restless legs syndrome and sleep bruxism: prevalence and association among Canadians. Sleep 1994;17:739–743
13. Bixler EO, Kales A, Vela-Bueno A, Jacoby JA, Scarone S, Soldatos CR. Nocturnal myoclonus and nocturnal myoclonic activity in the normal population. Res Commun Chem Pathol Pharmacol 1982;36:129–140
14. Ancoli-Israel S, Kripke DF, Mason W, Kaplan OJ. Sleep apnea and periodic movements in an aging sample. J Gerontol 1985;40:419–425
15. Mosko SS, Dickel MJ, Paul T, et al. Sleep apnea and sleep-related periodic leg movements in community resident seniors. J Am Geriatr Soc 1988;36:502–508
16. Bannerman C. Sleep disorders in the later years. Postgrad Med 1988;84:265–274
17. Trenkwalder C, Walters AS, Hening W. Periodic limb movements and restless legs syndrome. Neurol Clin 1996;14: 629–650
18. Overeem S, Mignot E, van Dijk JG, Lammers GJ. Narcolepsy: clinical features, new pathophysiologic insights, and future perspectives. J Clin Neurophysiol 2001;18:78–105
19. Bassetti C, Aldrich M. Narcolepsy. Neurol Clin 1996;14:545–571
20. Guilleminault C, Wilson RA, Dement WC. A study on cataplexy. Arch Neurol 1974;31:255–261
21. Robinson A, Guilleminault C. Narcolepsy. In: Chokroverly S, Daroff RB. Sleep Disorders Medicine. Boston: Butterworth Heinemann; 1999:427–440
22. Hublin S, Kaprio J, Partinen M, et al. The prevalence of narcolepsy: an epidemiological study of the Finnish twin cohort. Ann Neurol 1994;35:709–716
23. Billiard M, Alperovitch A, Perot C, et al. Excessive daytime somnolence in young men: prevalence and contributing factors. Sleep 1987;10:297–305
24. Dahlitz M, Parkes JD. Sleep paralysis. Lancet 1993;341:406–407
25. Roth B, Buuhova S, Berkova L. Familial sleep paralysis. Schweiz Arch Neurol Neurochir Psychiatr 1968;102:321–330
26. Aldrich M. The clinical spectrum of narcolepsy and idiopathic hypersomnia. Neurology 1996;46:393–401
27. Schenck CH, Bundlie SR, Mahowald MW. Human REM sleep chronic behavior disorders: a new category of parasomnia. Sleep Research 1985;14:208

28. Schenck CH, Bundlie SR, Patterson AL, Mahowald MW. Rapid eye movement sleep behavior disorder: a treatable parasomnia affecting older adults. JAMA 1987;257:1786–1789
29. Olson EJ, Boeve BF, Silber MH. Rapid eye movement sleep behaviour disorder: demographic, clinical and laboratory findings in 93 cases. Brain 2000;123(Pt 2):331–339
30. Husain AM, Miller PP, Carwile ST. REM sleep behavior disorder: potential relationship to post-traumatic stress disorder. J Clin Neurophysiol 2001;18(2):148–157
31. Schenck CH, Mahowald MW. REM sleep parasomnias. Neurol Clin 1996;14:697–720
32. Besset A. Influence of generalized seizures on sleep organization. In: Sterman MB, Shouse MN, Passouant P, eds. Sleep and Epilepsy. New York: Academic Press; 1982:339–346
33. Touchon J, Baldy-Moulinier M, Billiard M, Besset A, Valmier J, Cadilhac J. Organisation du sommeil dans l'epilepsie récente du lobe temporal avant et après traitment par carbamazepine. Rev Neurol 1987;143:462–467
34. Tachibana N, Shinde A, Ikeda A, Akiguchi I, Kimura J, Shibasaki H. Supplementary motor area seizure resembling sleep disorder. Sleep 1996;19(10):811–816
35. Crespel A, Baldy-Moulinier M, Coubes P. The relationship between sleep and epilepsy in frontal and temporal lobe epilepsies: practical and physiopathologic considerations. Epilepsia 1998;39(2):150–157
36. Bazil CW, Castro LHM, Walczak TS. Reduction of rapid eye movement sleep by diurnal and nocturnal seizures in temporal lobe epilepsy. Arch Neurol 2000;57:363–368
37. Touchon J, Baldy-Moulinier M, Billiard M, et al. Sleep organization and epilepsy. In: Degen R, Rodin EA, eds. Epilepsy, Sleep, and Sleep Deprivation. Amsterdam: Elsevier; 1991:73–81
38. Bazil CW, Walczak TS. Effects of sleep and sleep stage on epileptic and nonepileptic seizures. Epilepsia 1997;38(1):56–62
39. Herman ST, Walczak TS, Bazil CW. Distribution of partial seizures during the sleep-wake cycle: differences by seizure onset site. Neurology 2001;56:1453–1458
40. Park SA, Lee BI, Lee SJ, Kim WJ, Lee JH, Kim JY. Clinical courses of pure sleep epilepsies. Seizure 1998;7:369–377
41. Yaqub BA, Waheed G, Kabiraj MM. Nocturnal epilepsies in adults. Seizure 1997;6:145–149
42. Malow BA, Passaro EA, Hall JH, et al. Sleep deprivation does not increase seizure frequency during long term monitoring. Epilepsia 1999;40(suppl 7):99–100
43. Quigg M, Straume M, Menaker M, Bertram EH. Temporal distribution of partial seizures: comparison of an animal model with human partial epilepsy. Ann Neurol 1998;43:748–755
44. Bazil CW, Short DW, Crispin D, Zheng W. Patients with intractable epilepsy have low melatonin, which increases following seizures. Neurology 2000;55:1746–1748
45. Fauteck JD, Schmidt H, Lerchl A, Kurlemann G, Wittkowski W. Melatonin in epilepsy: first results of replacement therapy and first clinical results. Biol Signals Recept 1999; 8:105–110
46. Peled N, Shorer Z, Peled E, Pillar G. Melatonin effect on seizures in children with severe neurologic deficit disorders. Epilepsia 2001;42:1208–1210
47. Wolf P, Schmitt JJ. Awakening epilepsies and juvenile myoclonic epilepsy. In: Bazil CW, Malow BA, Sammaritano MR, eds. Sleep and Epilepsy: The Clinical Spectrum. Elsevier: Amsterdam; 2002:237–243
48. Shinnar S, Berg AT, Moshe SL, et al. Discontinuing antiepileptic drugs in children with epilepsy: a prospective study. Ann Neurol 1994;35:534–545
49. Blom S, Heijbel J, Bergfors PG. Benign epilepsy of children with centro-temporal EEG foci. Prevalence and follow-up study of 40 patients. Epilepsia 1972;13:609–619
50. Blom S, Heijbel J. Benign epilepsy of children with centro-temporal EEG foci. Discharge rate during sleep. Epilepsia 1975;16:133–140
51. Hirsch E, Marescaux P, Maquet P, et al. Landau-Kleffner syndrome: a clinical and EEG study of five cases. Epilepsia 1990;31:756–767
52. O'Regan ME, Brown JK, Goodwin GM, Clarke M. Epileptic aphasia: a consequence of regional hypometabolic encephalopathy? Dev Med Child Neurol 1998;40:508–516
53. Mendez M, Radtke RA. Interactions between sleep and epilepsy. J Clin Neurophysiol 2001;18:106–127
54. Provini F, Plazzi G, Tinuper P, Vandi S, Lugaresi E, Montagna P. Nocturnal frontal lobe epilepsy. A clinical and polygraphic overview of 100 consecutive cases. Brain 1999; 122:1017–1031
55. Oldani A, Zucconi M, Asselta R, et al. Autosomal dominant nocturnal frontal lobe epilepsy. A video-polysomnographic and genetic appraisal of 40 patients and delineation of the epileptic syndrome. Brain 1998;121:205–223