Christian Guilleminault,[1] *M.D.; Damien Leger,*[2] *M.D.; Pierre Philip,*[3] *M.D.; and Maurice M. Ohayon,*[4] *M.D., D.Sc.*

Nocturnal Wandering and Violence: Review of a Sleep Clinic Population*

REFERENCE: Guilleminault C, Leger D, Philip P, Ohayon MM. Nocturnal wandering and violence: review of a sleep clinic population. J Forensic Sci 1998;43(1):158–163.

ABSTRACT: Sleep consists of two complex states—NREM and REM sleep—and disturbances of the boundaries between the states of sleep and wakefulness may result in violence. We investigated our population for reports of violence associated with sleep. REM behavior disorder is rarely associated with injury to the sufferer or others. NREM sleep related nocturnal wandering associated with self-inflicted injuries has variable etiologies. In the elderly, it is associated with dementia. In young individuals, it may be associated with mesio-temporal or mesio-frontal foci and an indication of a complex partial seizure. It also may be related to abnormal alertness and is associated with excessive daytime sleepiness, micro-sleeps, and hypnagogic hallucinations in sleep disorders such as narcolepsy or sleep disordered breathing.

KEYWORDS: forensic science, violence, sleep, somnambulism, REM behavior disorders, excessive daytime sleepiness, hypnagogic hallucinations, slow wave sleep, sleep deprivation

Violence during sleep has been the source of several ongoing controversies: Is the subject ever "asleep" during violent acts, do the events occur out of sleep, or is there an intermediate or borderland period between sleep and wake? At what point does full alertness occur? Is there a decrease or absence of judgment when violent actions occur within this ill-defined borderland between wake and sleep? Based on available data, if one accepts the existence of this borderland of sleep and abnormal states of alertness, how long could this "abnormal state" last? Is there some event during sleep that influences the violent behavior? Is the state of alertness during the abnormal behavior different from "normal" wake, and, if different, how and based on what objective information? Are there any differences in the reports, clinical histories, and polysomnographic recordings of subjects whose nocturnal wanderings are not associated with violence and those whose are?

Currently, these questions remain unanswered. In the following presentation, we describe the relationship between the two sleep states, REM and nonREM, and the occurrence of violence during the nocturnal period; we outline when the abnormal behavior is a sleep phenomenon and when an abnormal arousal out of a sleep state occurs prior to violence; and we consider the interaction between specific sleep disorders and nocturnal violence.

[1]Stanford University School of Medicine, Sleep Disorders Center, Stanford, CA.
[2]Unité de Sommeil de L'Hôtel-Dieu, Paris, France.
[3]Laboratoire Du Sommeil, C.H.R. Bordeaux, Hopital Saint André, Bordeaux, France.
[4]Centre de Recherche Philippe Pinel de Montréal, Montreal, Quebec, Canada.
*This work is attributed to Stanford University School of Medicine, Sleep Disorders Center, Stanford, CA.
Received 7 April 1997; and in revised form 16 May 1997; accepted 16 May 1997.

REM and NonREM Sleep

Sleep is not a single state and, since 1953, it has been subdivided into Rapid Eye Movement (REM) sleep and nonREM sleep. These two states are present at birth and their polygraphic features mature progressively during the first few months of life. The proportion of REM to nonREM sleep varies depending on age. In middle-aged adults REM sleep represents about 20% of total sleep time and appears in a cyclical fashion during the night. The proportion of REM to nonREM sleep increases from the first to the last cycle, thus the longest period of REM sleep occurs at the end of the sleep period (1).

Neuronal firing is different during nonREM and REM sleep, and the neuronal firing of both sleep states is different from wake. It appears that the neuronal networks are organized differently during wake, NREM, and REM sleep. In sleep, as in wake, our brain's cortical electrical activity never ceases. Its absence is one of the criteria for brain death. Subjects can spontaneously enter and return from each of these states depending on the stimuli; wakefulness, for example, is associated with the continuous integration of and response to stimuli. Mentation occurs during all states of alertness, REM sleep, nonREM sleep, and waking, but there are different types of mentation during each. REM sleep is associated with dreams, i.e., constructed vignettes of variable duration. Recently, positron emission tomography (PET) studies have shown increased metabolic activity in the amygdala (a structure associated with memory and autonomic nervous system control) and brain-stem during REM sleep (2).

Violence During REM Sleep

REM sleep is also normally associated with antigravity muscle atonia. In the early 80s, several Japanese teams found that REM sleep related muscle atonia could be absent during REM sleep and be responsible for abnormal movements and activity during sleep (3,4). In 1986, Quera-Salva and Guilleminault (5) found that patients with olivoponto cerebellum atrophy (OPCA) frequently acted out their dreams. This was related to the disappearance of REM sleep related muscle atonia. Finally, Schenck et al. (6) were the first to publish a complete description of the syndrome, calling it "REM sleep behavior disorder." They found it was also present in individuals without neurological lesions (7).

We reviewed 48 subjects (18 women) diagnosed with REM behavior disorder in our clinic. To be included, the subjects' bed-partners must have documented the abnormal nocturnal behavior, the events must have occurred several times during the past 6 months and the abnormal behavior must have been successfully recorded in the laboratory with nocturnal polysomnography. Mean age was 57 ± 11 years. Five subjects presented with brain-stem lesions (multiple sclerosis and OPCA) and there was the possibility of hemodynamic problems in 16—ranging from presence of small lacunae with mild cerebral atrophy in four subjects to cardio-vascular syndromes of variable severity in the others (including isolated hypertension). All other subjects had no neurological syndrome that could explain the abnormal nocturnal behavior.

Of this entire group, only one subject reported an episode that qualified as "violence against others." He was a 51-year-old man who, during one episode of REM behavior disorder, placed his hands on his wife's neck and pressed, though not hard enough to be considered strangling. When awaken he reported dreaming about twisting the head of a chicken (an activity related to his work). Self-inflicted injuries were reported more frequently. They usually involved only bruises, but we saw 3 subjects with fractures including a compound fracture of a finger. These injuries usually were related to large movements of the arms, during good or bad dreams, and the resulting contact with furniture or walls.

Antidepressant Induced REM Behavior Disorders

There is an iatrogenic form of the syndrome that is reversible with interruption of drug intake. It was first mentioned in the early 80s, well before the attribution of a name to the abnormal behavior. Guilleminault et al. (8) demonstrated that tricyclic medications and some of the new 5HT re-uptake blockers, used commonly for depression or obsessive compulsive disorders (OCD), eliminate REM sleep atonia. Physicians treating narcoleptic patients take advantage of this pharmacological side-effect, using the medication to reduce the muscle atonia associated with cataplexy. This pharmacological property increases the number of small abnormal movements during sleep and can also be responsible for abnormal activity during REM sleep.

A review of our database revealed 19 narcoleptic patients and 6 non-narcoleptic patients who had been treated for depression or OCD where such an iatrogenic effect was seen. Seven subjects suffered self-inflicted injuries, causing mostly bruises and one deep laceration above the eye, that completely stopped after elimination of the guilty pharmacological agent. None had inflicted injury on others.

NonREM Sleep Related Nocturnal Wanderings and Night Terrors

Most commonly, somnambulism and night terrors have been associated with episodes of incomplete arousal from nonREM sleep. They are characterized by automatic behavior where the subject is usually oblivious of the surroundings and mostly unresponsive to external stimuli. These subjects exhibit increased respiration and heart rate along with vocalizations and complex movements. Broughton and Gastaut (9,10) were the first to suggest that nocturnal wandering was a disorder out of nonREM sleep. Since then, several studies have substantiated this claim.

A review of the patients in our clinic database identified 71 patients with nocturnal wanderings. Violent episodes were mostly seen during nonREM sleep related nocturnal wandering. We were able to capture a nonREM sleep related violent episode on a polygraph in only three subjects. We did, however, record many nocturnal wanderings in subjects who were reported to have repetitive episodes of nocturnal violence, some of which injured the patient or others. Nocturnal wanderings always occurred out of sleep, and upon arousal from nonREM sleep (i.e., nonREM sleep was the last sleep state recorded before the episode of nocturnal wandering.) The population of nocturnal wanderers had a mean age of 43 ± 28 years and included 30 women. In this population, 24 individuals had a history of violent nocturnal events. The mean age of this group (41 ± 26 years) was not statistically different from the nonviolent group, but there was a major difference in sex ratio with 36 men and only 7 women in the violent group. Analyses of clinical histories and polygraphic recordings did not allow the identification of another feature that was different between the violent and nonviolent groups. The only hypothesis is that men, who often move with more physical force, may be at greater risk when moving around confused and disoriented during the nocturnal wanderings.

We also evaluated the patient population by age and identified two distinct age peaks. There was a young group of 44 subjects (18 women) whose mean age was 18 ± 5 years that included 29 subjects (7 women) from the violent group. And there was an elderly group of 27 subjects (12 women), mean age 64 ± 6 years, that included 7 subjects (0 women) from the violent group. The two major subject groups i.e., "young" and "old," presented with distinct and interesting differences. Classically, the young group has been defined as presenting "somnambulism" while the older group is more commonly associated with "confusional arousals," despite the fact that the boundary between these two terms is vague.

The Elderly Group

Clinical Description

This group had no history of sleep walking, night terrors or similar parasomnias before 50 years of age. All subjects presented with a neurological problem. The most common was dementia (21 subjects)—independently of whether it was Alzheimer's type or vascular related dementia, 4 subjects had Parkinson's disease, 3 subjects had problems that occurred following open-heart surgery (2) or myocardial infarction (1). In these 3 subjects, despite absence of clear focal lesions at magnetic resonance imaging (MRI) scan, a neurological cause, secondary to brain anoxia was suspected.

All subjects presented the same clinical pattern: Episodes, occurred at least once a week. The severity of the episodes varied depending on the night and several episodes could occur per night. Most episodes lasted from than 5 min to half an hour and were followed by long-lasting disorientation that was not consistently reduced by lighting of the room. Due to the repetitive nature of the events, care-givers had commonly tried a variety of approaches, such as a dim light in the bedroom, without much success and in one subject the hypnagogic hallucinations were clearly originating from visions around the dim light. The nocturnal wanderings were associated with utterances ranging from incomprehensible mumbling to distinct insults or profanities and full but confused sentences. Occasionally the subjects exhibited inappropriate behavior such as urinating or defecating in closets or in the bedroom, turning on gas furnaces without lighting the fire, opening all windows in the house, emptying the refrigerator, etc.

The severity of neurological disease in the violent group was not greater than that of the nonviolent group, but all subjects presented cognitive impairment while awake. Our investigation of the available MRI scans indicated generalized lesions, most commonly ce-

rebral atrophy, but the violent subjects had no specific focal lesion in common and their scans were not significantly different from the nonviolent subjects.

With the exception of one subject, who had a history of repeated attacks using a variety of objects as weapons (chairs, tray, vase, TV, etc.) on the care-givers who tried to quiet him, most of the subjects did not present with a repetitive pattern of aggression toward others. However, the care-givers, often also elderly, reported isolated events leading to injuries ranging from a broken arm or a broken rib to, more commonly, bruises secondary to punches in the face or on the body.

Polysomnography and Ambulatory Recordings

Review of the polygraphic recordings revealed that nocturnal sleep was disrupted regularly in both violent and nonviolent subjects. Sleep logs kept by caregivers indicated frequent awakenings during sleep not necessarily associated with wanderings. These sleep logs were confirmed by actigraphic recordings (Miniloger, Ambulatory Monitoring, Inc. New York) that indicated an overall very large increase in "movement time" taken as an index of "wake" during the night. For the total study group, during a mean bedtime of 510 $\pm$ 85 min, the mean movement time in bed was 312 $\pm$ 71 min with periods of no movement scattered throughout the nocturnal period. Actigraphy was obtained for a minimum of four and a maximum of seven consecutive days. Polygraphic recordings were attempted in all 71 patients. Due to the laboratory conditions and monitoring equipment, 19 of the subjects presented a further reduction of sleep compared to actigraphic data, and five individuals had no recognizable sleep electroencephalogram (EEG). Thirty-one of the subjects had an additional series of ambulatory recordings with monitoring of EEG, electrooculogram (EOG) and chin electromyogram (EMG) at home (Oxford Medilog, Oxford, UK).

Nocturnal wanderings always followed minutes of "movement time" according to the actigraphs. The laboratory and home-ambulatory recordings indicated that out of bed events were always preceded by several minutes (mean 7.6 $\pm$ 3.8) of wake EEG. In our recordings, we did not have a single instance of an abrupt switch from sleep to wake with the onset of the nocturnal wandering. In every case, the last sleep EEG noted prior to the episode of nocturnal wandering was NREM stage 1 or stage 2. In interviews, subjects and care-givers described auditory, visual, and somesthesic hallucinations at the beginning of some of the wanderings, but at the time of the recordings such hypnagogic hallucinations were only seen in 6 subjects (~20% of the population). Behaviorally, subjects appeared profoundly confused and disoriented, and only 2/6 subjects who experienced hypnagogic hallucinations during the recording were in the violent group.

Typically these patients had been classified with "sundown syndrome." However, the clinical definition of this term is vague. In summary, independently of the presence or absence of nocturnal violence, in this older group: (a) There was no clinical correlation between cognitive dysfunction and nocturnal wanderings. All of the subjects presented cognitive dysfunction, with a variable degree of intellectual impairment ranging from minimal memory dysfunction in our post-myocardial infarction subject to generalized cognitive deterioration in one Parkinson's patient with dementia. (b) There was no correlation between MRI results and the presence of nocturnal wanderings. (c) All subjects with nocturnal wanderings had very poor nocturnal sleep with significant sleep fragmentation and daytime napping. (d) Nocturnal wanderings always occurred after EEG demonstrated periods of wake. (e) The degree of confusion and disorientation during the nocturnal wandering was not clinically different in the violent and nonviolent groups.

The Young Adult Group

Clinical Description

These individuals were very different from the elderly group. They appeared to be healthy young adults who reported only problems linked to sleep. Typically, their somnambulism had been present for many years, often with onset during childhood and variable occurrence in the intervening period. In our population, the nocturnal wanderings were associated with nightmares and/or night terrors that may or may not have declined in frequency and severity since childhood.

In all of the subjects in our young violent group, an especially severe violent episode was the major stimulus for seeking medical help. More than 70% of the reported, self-inflicted injuries in our population were caused by going through glass, with or without a fall from height (i.e., defenestration). One case was not included in the tally as the exact circumstances of death were not certain, but there was strong suspicion of somnambulism leading to the fall from a third floor bedroom window, with subsequent broken cervical vertebrae, in this chronic sleep walker. The reports of self-inflicted injuries included nearly-severed limbs, deep lacerations, torn tendons and ligaments, severed arteries and nerves, and broken bones. The harmful behavior toward others included violent physical attacks resulting in bones and bruises secondary to punches and kicks or from objects hurled at individuals, defenestration, and shoving over furniture or down stairways.

There were several features that were common during the violent behavior: (1) The individual(s) under attack were in close proximity to the perpetrator, possibly asleep in bed or the victim was simply in the pathway of the somnambulist during an episode (they can be very active with running or escape behavior) and was violently brushed aside. (2) The victim tried to stop the behavior or limit the movement of the subject during the somnambulistic episode. This has been the number one cause of bruises received by our monitoring team in the laboratory, with bruises inflicted by arm movements from the subject or secondary to trays or monitoring medical equipment hurled at the advancing technician or physician coming to restrain the patient. (3) Aggression was mostly in response to a perceived threat to the subject or to a loved one who may become the victim of the injury as a consequence. One of our patients, thinking that there was a imminent danger (earthquake, fire, etc.) and that he had to "save his wife," would regularly, brutally throw her out of bed onto the floor and drag her out of the room. Interestingly, the consult occurred only after one episode resulted in multiple broken ribs, despite the fact that this behavior was repetitive. Another patient, responding to perceived threats, repeatedly would run into his children's rooms, pick them up from their beds and bring them, one after the other, into the garden. Once again, despite chronic behavior, the patient consulted a physician only after dropping one child onto a stone causing an fractured arm. Another father threw his sleeping infant through a 3rd floor window to save the infant from "a crumbling wall due to an earthquake." Luckily the infant was not hurt. (4) Subjects often had night terrors associated with the somnambulistic episode. These night terrors were sometimes a well-developed perception of a dangerous situation—i.e., fire, earthquake, hurricane, burglars in the house, being buried alive, being raped or killed or attacked by animals, etc.—but sometimes there was only the feeling of

that a few of these young subjects presented epileptic discharges with activation during nonREM sleep (15–18). It has been calculated that partial complex seizures may be associated with up to 1% of somnambulistic events or night terror episodes. Tassinari et al. (19) have also emphasized that, in brain impaired children, nonepileptic and epileptic somnambulism and night terrors may co-exist, though we observed this in only one of our pediatric patients. In this patient, the onset of a night terror occurred with autonomic nervous system associated symptoms, including tachypnea, secondary to the abrupt arousal from sleep and the hyperventilation, focal epileptic discharges and secondary grand mal seizures or nocturnal wandering was observed.

We noted an over-representation of complex partial seizures from sleep in our young violent group ($N = 4$; mean age: 19 years), compared to the expected frequency of somnambulistic episodes related to seizure despite the overall low frequency of this epileptic syndrome. Clinically, the epileptic nocturnal wandering is very stereotypic, and the violent behavior is often more forceful (not necessarily resulting in injuries to self or others). These features may help to dissociate those somnambulistic episodes related to partial complex seizure from the nonepileptic ones. These clinical reports are, however, difficult to use when considering an independent case and is a finding based on population analysis. None of the other classic criteria, outlined below, allow the affirmation of the presence/absence of epilepsy except specific recordings: Classically nonepileptic episodes of somnambulism occur from stage 4 NREM sleep, during the first third of the night, associated with autonomic nervous system changes (tachypnea, tachycardia, sweat, etc.) and amnesia of event. But systematic investigations have shown that complex partial seizures may lead to events with exactly similar patterns and nonepileptic somnambulistic episodes may be seen out of stage 2 NREM sleep, anytime during the night, be repetitive during the same night and may not be associated with severe autonomic reaction. The only appropriate diagnostic test is complete investigation of a seizure disorder during wake and during sleep, with appropriate EEG montages, and with tests possibly performed after sleep deprivation. The foci responsible for the somnambulistic episodes are difficult to investigate. They are mesio-temporal and mesio-frontal, no other epileptic focus was noted in our patient population.

Sleep Disorders and Violence During Sleep

Sleep Disordered Breathing

Despite the frequency of sleep disordered breathing in our patient population, few of these subjects reported nocturnal violent activity. We reviewed two databases that included 8,805 patients with abnormal breathing during sleep. Several features, however, indicate that violence against others could potentially be seen in that population. First, epileptic seizures during sleep, related to the severe hypoxemia that may occur in certain polymorbid subjects with severe android obesity, could lead to abnormal behavior. We observed fewer hypoxic seizures in our surveyed population than that reported by the Bologna group (20). Only 3 subjects were identified with this problem, and one had a cardiac arrest and secondary brain death during one of these seizures. The most common injury inflicted by these patient on others is related to the broad arm movements seen at the end of an obstructive apnea in an obese, tall subject. These have resulted in blows to the unsuspecting bed partner, leading to bruises and their departure to another bedroom. This was mentioned in 174 charts (i.e., about 2% of the population). Self-inflicted injuries are mentioned more often and are usually related to falls from beds, again in association with abnormal movements related to apnea induced hypoxemia. Falls from bed were mentioned by 5% of our population (451 subjects) and fractures (most common, hand, finger, forearm) were indicated by 128 subjects (about 1.5% of the surveyed population).

Non-obese subjects with the Upper Airway Resistance Syndrome may also present nocturnal wanderings. The induction of a somnambulistic episode by an abnormal breathing event may reveal the sleep related breathing disorder. Our database on adults has little information on the frequency of this problem, but we have very good information on the frequency of this induction in children. After a review of 469 children with sleep disordered breathing, 143 children had somnambulistic episodes or night terrors induced by the abnormal breathing patterns. None of these children had injured themselves or others during the somnambulistic episodes (21).

Narcolepsy

Narcolepsy is well known for its association with daytime sleepiness, cataplexy, sleep paralysis, and hypnagogic and hypnopompic hallucinations. These last symptoms, which occur against a background of excessive sleepiness have been responsible for significant self-inflicted injuries. Over the years, we have registered approximately 1,000 narcoleptics at Stanford. The severity of their symptoms varied widely and may change throughout the life of the patient, particularly cataplexy, sleep paralysis and hypnagogic hallucinations. We have 7 patients who have acknowledged that they slept with arms (knives and loaded guns) under their pillows because they were so frightened by their hypnagogic hallucinations and had difficulty dissociating them from reality at the time of their occurrence (22). Four of these 7 subjects acknowledged having shot at their hallucinations at least once, fortunately without causing any injuries. Self-inflicted injuries are much more common and are related to the excessive sleepiness experienced by narcoleptics. A much larger percentage of our narcoleptics smoke cigarettes, compared with the general population. Sixty-seven percent of narcoleptics acknowledge having burned themselves due to sleepiness while smoking, 18% acknowledge having smoked in bed and burned sheets and blankets, and 1% of our subjects have been involved in a fire that required outside intervention—resulting in 8 subjects with third degree burns and, in one case, a completely destroyed home. Sleepiness is also a cause of many industrial and driving accidents that have been recently well-outlined in many publications.

Conclusion

The altered state of consciousness associated with excessive sleepiness and polygraphic documentation of micro-sleeps were well-investigated decades ago. Sleep is associated with amnesia and the retrograde amnesia that occurs at sleep onset is familiar to all, and has also been well-studied. The biological properties associated with sleep have an impact on judgment, and sleepiness during the daytime or abnormal sleep at night may lead to abnormal behavior. The abnormal behavior may be even more significant if the sleep disturbance occurs in a subject with pathological neurological syndromes. In cases of violence inflicted on self or others, it is obvious that the society will question the legal responsibility of the individual involved, assessing his or her judgmental capabilities at the time of the event and seeking avoidance of further threat. There is a certain irony in the fact that, as society seeks to defend itself against a sleep related pathology there is not a single country

in which sleep medicine is officially recognized as a part of any medical school curriculum. Then, in the rare countries where medical insurance companies will pay for the investigation and treatment of some sleep disorders, most causes of the violence related to sleep are not covered and cannot be appropriately investigated or treated.

Independently of these ironies, the fact remains that violence related to sleep/wake disruption does occur (23). Undoubtedly the legal system will immediately consider issues related to decreased responsibility or mitigation in sentencing in high profile trials, while the real issue is appropriate recognition and treatment of the diverse problems underlying the nocturnal wanderings as prevention against violence to the patient and others. The pattern of violence against others is mostly an unconstructed violence against a bystander who may not be recognized by the wandering subject. The most likely bystander, given the time these nocturnal episodes occur, is a caregiver or family member, often leading to a heart breaking situation for the perpetrator of the violent act.

A better understanding of sleep physiology and disturbances of the sleep/wake cycle will help us control nocturnal wandering that may end in violence and sometimes injury to others, even death.

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Additional information and reprint requests:
Dr. Christian Guilleminault
Stanford University School of Medicine
Sleep Disorders Center
01 Quarry Road Suite 3301-A
Stanford, CA 94305