Nocturnal Frontal Lobe Epilepsy: Intracerebral Recordings of Paroxysmal Motor Attacks with Increasing Complexity

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**Purposes:** To show the results of the investigation conducted with intracerebral electrodes in a patient with drug-resistant nocturnal frontal lobe epilepsy, characterized by sleep-related paroxysmal motor attacks of increasing complexity ranging from simple and brief stereotyped motor events to paroxysmal arousals and major attacks.

**Methods:** The patient was studied with long-term video-stereo-electroencephalographic monitoring by means of stereotactically implanted intracerebral electrodes.

**Results:** Video-stereo-electroencephalography demonstrated that minor events and paroxysmal arousals, as well as major attacks, were correlated with a discharge in the right supplementary motor area and central cingulate gyrus. The increasing complexity of these sleep-related ictal motor behaviors reflected a different pattern of discharge, with a progressive spread to other frontal and extrafrontal areas in the fully developed attacks. Surgical resection of the right supplementary motor area and central cingulate gyrus was performed. In the 5 years since the operation, the patient has remained completely seizure free.

**Conclusion:** This study clearly demonstrates the ictal origin of minor events in nocturnal frontal lobe epilepsy. The increasing complexity of the motor behaviors from minor to major attacks reflects different duration, amplitude, and spread of the epileptic discharge.

**Key Words:** Nocturnal frontal lobe epilepsy, paroxysmal arousals, paroxysmal motor attacks, EEG intracerebral recordings

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**INTRODUCTION**

THE CLINICAL FEATURES OF NOCTURNAL FRONTAL LOBE EPILEPSY (NFLE) CONSIST OF A SPECTRUM OF PAROXYSMAL MOTOR MANIFESTATIONS OF INCREASING COMPLEXITY AND DURATION OCCURRING DURING NON–RAPID- EYE-MOVEMENT (NREM) SLEEP. These include a) minor events,\(^1\,^5\) represented by short-lasting (2–4 seconds) stereotyped movements involving the limbs, the axial musculature and/or the head; b) paroxysmal arousals (PA),\(^2\,^4\) characterized by frequent and recurring abrupt brief arousals lasting about 5 to 10 seconds, accompanied by stereotyped movements (trunk and head elevation) often associated with vocalization and frightened expression; and c) major attacks, previously defined under the term of nocturnal paroxysmal dystonia (NPD),\(^2\,^4\,^6\,^7\) which are characterized by stereotyped movements such as asymmetric tonic or dystonic posturing or other bizarre behaviors (choreoathetoid and ballistic movements of the limbs) lasting about 20 to 30 seconds.

These manifestations may coexist in the same patient,\(^1\,^5\,^7\) and it has been postulated that the increasing complexity of the ictal motor behavior reflects a different duration and propagation of the discharge within the frontal lobe.\(^4\) Unfortunately, this hypothesis has not been corroborated by conventional electrophysiologic data, since, in most of these cases, scalp electroencephalography (EEG) does not show definite ictal abnormalities.\(^1\,^5\) This may be explained by an origin of the discharge in structures whose activity is not easily detectable by EEG surface electrodes, as the mesial frontal cortex. Indeed some NPD attacks seem to originate in the supplementary motor area (SMA) or the cingulate gyrus (CG).\(^8\,^11\)

A definite electroclinical correlation of the whole spectrum of nocturnal paroxysmal motor events occurring in NFLE is still lacking. Moreover, the possible ictal origin of minor episodes has not yet been assessed by electrophysiologic investigations.

The present report is the first demonstration, by the employment of intracerebral recordings and with the corroboration of the postoperative outcome, that these seizures can be provoked by discharges involving primarily the SMA and the CG.

**CASE REPORT**

This 39-year-old woman, with no familial history of neurologic disorders (epilepsy, parasomnias, or both), had her first epileptic seizures at 8 years of age. These occurred during wakefulness and consisted of a “staring,” lasting some seconds without automatisms or motor behaviors. After the introduction of carbamazepine, she remained seizure free for 5 years. Seizures reappeared at the age of 13, and they occurred only during sleep with different clinical manifestations, which remained similar to those presented during the hospitalization in our center. Over the years, different antiepileptic drugs in monotherapy or polytherapy were administered, but no regimen resulted in satisfactory seizure control. At the age of 31, she was referred to our center for a presurgical evaluation. She took phenytoin (300 mg/day) and primidone (500 mg/day). Seizure frequency was 1 to 2 per night. They were described as sudden elevation of the trunk and flexion with tonic contraction of the arms and legs, followed by a left trunk rotation. These movements were generally accompanied by a rhythmic cry and a sensation of anguish. Moreover, the patient complained of nocturnal discontinuity of sleep, which was disrupted by frequent awakenings, and of excessive diurnal sleepiness. Her husband confirmed the presence of an agitated and fragmented sleep. The level of sleepiness was assessed by applying the Epworth Sleepiness Scale (ESS), a validated questionnaire measuring the general level of daytime sleepiness with good correlation with objective measures of sleep propensity.\(^12\,^13\) The score of the ESS before the operation was 18. Neurologic examination and cerebral magnetic resonance imaging (MRI) were normal. During scalp video-EEG investigation, we recorded 2 major attacks similar to those reported by the patient, occurring in...
NREM sleep (stages 2 and 3). Moreover a high number of other motor attacks, with a widely different duration and intensity but with highly stereotyped clinical features, were observed during NREM sleep. We divided the attacks into minor events, PAs, and major attacks. Minor events, which lasted 2 to 3 seconds, consisted of a left head deviation with vocalization, sometimes followed by an abrupt rising of the left arm and often accompanied by face touching with the right hand. The PAs consisted of minor events immediately followed by head and trunk elevation with frightened expression. The patient could sit up on the bed looking around for a few seconds and then rapidly fall asleep again. If tested immediately after these episodes, the patient ascribed the awakening to a bad dream.

Major attacks lasted 20 to 30 seconds and consisted of a PA followed by sudden and violent asymmetrical tonic posturing of the limbs with preserved consciousness and fear. Minor events and PAs were not accompanied by significant ictal scalp EEG modifications, while in major attacks the EEG showed an initial flattening of activity over the frontal regions, predominantly on the right side, with the traces being rapidly obscured by artifacts. The clinical and EEG features suggested a right frontal origin of these episodes. The patient underwent an individualized investigation with stereotactically implanted intracerebral multilead electrodes (SEEG) for a careful definition of the epileptogenic zone for surgical purposes. The 16 implanted electrodes investigated, in the right hemisphere—the SMA; the anterior and central CG; the superior, middle and inferior frontal gyri; the orbital gyrus; the amygdala; the temporal pole; the middle temporal gyrus—and, in the left hemisphere, the SMA, the anterior CG, the orbital gyrus, and the amygdala (Figure 1). A postimplantation MRI was obtained in order to confirm the actual position of each electrode.

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DISCUSSION

Patients affected by NFLE can display paroxysmal motor attacks during sleep with different duration and intensity, ranging from simple and brief stereotyped events to PAs and to major attacks, also defined as NPD. Our case report strongly supports the assumption that the increasing complexity and duration of the paroxysmal motor episodes may reflect a different pattern of the discharge, with a progressive spread of activation of frontal brain areas. Scalp ictal EEG and careful scrutiny of the ictal clinical modifications occurring even during minor events, despite an unremarkable MRI, indicated the right frontal lobe as the possible site of seizure onset. The SEEG recordings showed that minor events, PAs, and major attacks originated in the right SMA, with the increasing complexity of the motor behaviors reflecting different duration, amplitude, and spread of the discharge. The electrical features of PAs were similar to those observed during minor events, with a higher amplitude and longer duration of the discharge within the SMA, which also involved...
the central CG. The onset of the major attacks showed the same electrophysiological characteristics of PAs; the subsequent clinical evolution into asymmetrical tonic posturing of the limbs was correlated to the appearance of a low-voltage fast activity involving the right SMA and the right central CG. Moreover, the involvement of other structures, such as the ipsilateral anterior CG, the lateral frontal and temporal cortex, and the contralateral SMA, suggests that a complex anatomo-functional network could play a role in this kind of manifestation. However, the excellent outcome after the resection of the right SMA and central CG proves that these structures played the primary role in the genesis and maintenance of the seizure disorder per se.

Nevertheless, we are not tempted to assign to the SMA and the CG an exclusive role in the generation of such sleep-related motor attacks based only on the results of a single case. We are well aware of the clinical and EEG interindividual variability in NFLE. Different kinds of fully developed major attacks associated with minor events and PAs have been described, ranging from tonic-dystonic seizures to choreoathetoid and ballistic behaviors. This may depend on the brain areas where the ictal discharge originates and on its spatial-temporal organization. Moreover, it has been reported that even temporal lobe epilepsy may manifest itself with a clinical seizure pattern similar to that observed in NFLE.
In conclusion, this study, though limited to a single case, proves the epileptic origin of minor motor events occurring during sleep in the NFLE. The high recurrence of epileptic motor events may induce a sleep fragmentation leading to pathologic diurnal sleepiness as assessed by the ESS in our case. Before the operation, the ESS score of our patient was 18, indicating an excessive level of sleepiness, while after the operation, the score was 9, a value within the normal range, thus confirming the improvement of the diurnal level of vigilance.

REFERENCES