Original article with video sequences

Epileptic Disord 2015; 17 (3): 255-62

Seizure ending signs in patients with dyscognitive focal seizures*

Jay R. Gavvala, Elizabeth E. Gerard, Mícheál Macken, Stephan U. Schuele

Department of Neurology, Northwestern University Feinberg School of Medicine, Chicago, IL, USA

Received October 11, 2014; Accepted July 04, 2015

ABSTRACT – *Aim*. Signs indicating the end of a focal seizure with loss of awareness and/or responsiveness but without progression to focal or generalized motor symptoms are poorly defined and can be difficult to determine. Not recognizing the transition from ictal to postictal behaviour can affect seizure reporting accuracy by family members and may lead to delayed or a lack of examination during EEG monitoring, erroneous seizure localization and inadequate medical intervention for prolonged seizure duration.
Methods. Our epilepsy monitoring unit database was searched for focal seizures without secondary generalization for the period from 2007 to 2011. The first focal seizure in a patient with loss of awareness and/or responsiveness and/or behavioural arrest, with or without automatisms, was included. Seizures without objective symptoms or inadequate video-EEG quality were excluded.
Results. A total of 67 patients were included, with an average age of 41.7 years. Thirty-six of the patients had seizures from the left hemisphere and 29 from the right. All patients showed an abrupt change in motor activity and resumed contact with the environment as a sign of clinical seizure ending. Specific ending signs (nose wiping, coughing, sighing, throat clearing, or laughter) were seen in 23 of 47 of temporal lobe seizures and 7 of 20 extra-temporal seizures.
Conclusions. Seizure ending signs are often subtle and the most common finding is a sudden change in motor activity and resumption of contact with the environment. More distinct signs, such as nose wiping, coughing or throat clearing, are not specific to temporal lobe onset. A higher proportion of seizures during sleep went unexamined, compared to those during wakefulness. This demonstrates that seizure semiology can be very subtle and arousals from sleep during monitoring should alert staff. Patient accounts of seizure frequency appear to be unreliable and witness reports need to be taken into account. [*Published with video sequences*]

Key words: Seizure ending signs, dyscognitive seizures, seizure semiology

Correspondence:
Jay R. Gavvala
Department of Neurology,
Feinberg School of Medicine,
Northwestern University,
710 North Lake Shore Drive #1114,
Chicago, IL 60611, USA
<j.gavvala@northwestern.edu>

doi:10.1684/epd.2015.0763

*The preliminary data from this project was presented as a poster presentation at the American Epilepsy Society's annual meeting in December 2012.

Accurate clinical classification of seizures is an important tool to aid in prognosis and choice of appropriate treatment. Furthermore, analysis of seizure semiology is important to understand and characterize the onset and propagation of seizures (Loddenkemper and Kotagal, 2005; Rossetti and Kaplan, 2010; Stoyke *et al*., 2011). Unless the patient has intractable and relatively frequent seizures justifying admission for video-EEG monitoring, physicians usually rely on description of the event by patients or family members to assess these details, which has been shown to be less reliable than video review (Beniczky *et al*., 2012). Much attention has been given to auras as an indicator of seizure onset area and altered awareness as a measure of impairment (Palmini and Gloor, 1992; Widdess-Walsh *et al*., 2007).

Signs indicating the end of a focal seizure characterized by loss of awareness and/or responsiveness (LOA/R), so called "dyscognitive seizures", are poorly defined and may be difficult to detect (Blume *et al*., 2001; Berg *et al*., 2010). Not recognizing changes between ictal and post-ictal behaviour can affect accuracy of seizure reporting by family members which may conversely affect treatment regimen and may lead to an erroneous nursing response or seizure classification during video-EEG monitoring. While several studies have demonstrated the lateralizing value of ictal signs (Loddenkemper and Kotagal, 2005; Stoyke *et al*., 2011), very few have looked at postictal signs (last clonic jerk, postictal nose wiping, and postictal aphasia) (Leutmezer and Baumgartner, 2002). Without the ability to determine whether a seizure is over, postictal aphasia, for example, could be easily mistaken for ictal speech and lead to false lateralizing conclusions when based on a witness report or analysis of behaviour on video monitoring. However, there is limited literature characterizing the behaviour at the end of a dyscognitive focal seizure. The primary goal of this study was to identify and classify clinical signs heralding the end of dyscognitive focal seizures.

Methods

Our epilepsy monitoring unit (EMU) database was searched for all patients with dyscognitive focal seizures without secondary generalization for the period from 2007 to 2011. The first focal seizure in a patient with LOA/R and/or behavioural arrest and/or automatisms was included and seizures without objective symptoms were excluded. A total of eight patients with inadequate video-EEG quality were excluded. Seizure onset was defined based on both the first clinical and EEG change indicating seizure onset. Seizure end was determined by resolution of the ictal EEG pattern and apparent end of clinical symptoms. Review of EEG and video recordings were performed by board certified epileptologists and clinical neurophysiology fellows. In cases of disagreement regarding the end of electrographic seizures or dispute over clinical ending signs, a second board-certified epileptologist was consulted. Electrographic seizure ending was defined as the time showing resolution of ictal activity (repetitive spikes and spike-and-wave and rhythmic delta/theta activity). In patients where this was difficult to ascertain, we identified the end as the time immediately preceding clearly postictal activity. Examination of patients in the EMU primarily was performed by EEG technologists, although nurses in the EMU were also involved. All staff working in the EMU are trained in appropriate care and evaluation of persons with seizures according to the Northwestern seizure examination protocol. Two-tailed T tests were performed for statistical analysis using a P value of less than 0.05 to indicate significance.

Results

A total of 67 patients were included, with 20 men and 47 women and an average age of 41.7 years (19-80). Forty-seven had temporal lobe epilepsy and 20 had extra-temporal epilepsy. Thirty-six of the patients had seizures from the left hemisphere and 29 from the right. Average clinical duration was 1:26 minutes (0:14-10:36) and average electrographic duration was 1:28 minutes (0:05-10:38). Thirty-nine events occurred during wakefulness and 28 during stage II sleep or deeper (*table 1*).

Seizures during wakefulness

Of the 39 patients who had seizures during wakefulness, nine were not examined during their seizure. There were 22 button pushes during the seizure; seven by family members, five by staff and 10 by the patients, one of whom pushed the button after the seizure (*figure 1*). Four patients unsuccessfully tried to push the button at seizure onset. Eleven of 39 (28.2%) patients reported an aura, described as *déjà vu*, out of body experience, tingling, nausea, dizziness, or anxiety. A total of 19 patients (48.7%) were noted to develop automatisms during the electrographic seizure and resolution of automatisms prior to the end of the electrographic seizure was noted in 14. Four patients had cessation of automatisms correlating to the end of the electrographic seizure and one patient had automatisms that persisted into the postictal period (*figure 2A*). All patients (39 of 39) showed an abrupt change in motor activity and contact with the

Table 1. Demographics.

N		67
Gender		20 M, 47 F
Average age		41.7 (19 - 80 years)
Location	Temporal: Extra-temporal:	47 (20 specific ending signs) 20 (7 specific ending signs)
Stage	Awake: Sleep:	39/67 (58.2%) 28/67 (41.8%)
Average duration (min)	Clinical: EEG:	1:26 1:28
Lateralization	Left: Right:	36 (53.7%) 29 (43.3%)
Unexamined/total seizures	Awake: Sleep:	9/39 (23.1%) 13/28 (46.4%)

environment as a clinical seizure ending sign (*video sequence 1*). Specific ending signs were seen in 15 of 39 events (38.5%): nose wiping (*video sequence 2*) in seven, coughing in four, and throat clearing or deep sighing (*video sequence 3*) in four (*figure 2B*). All seizures that occurred during the awake state resulted in the patient remaining awake. A higher number of total button pushes (p=0.08) and patient button pushes (p=0.06) occurred during the awake state compared to sleep.

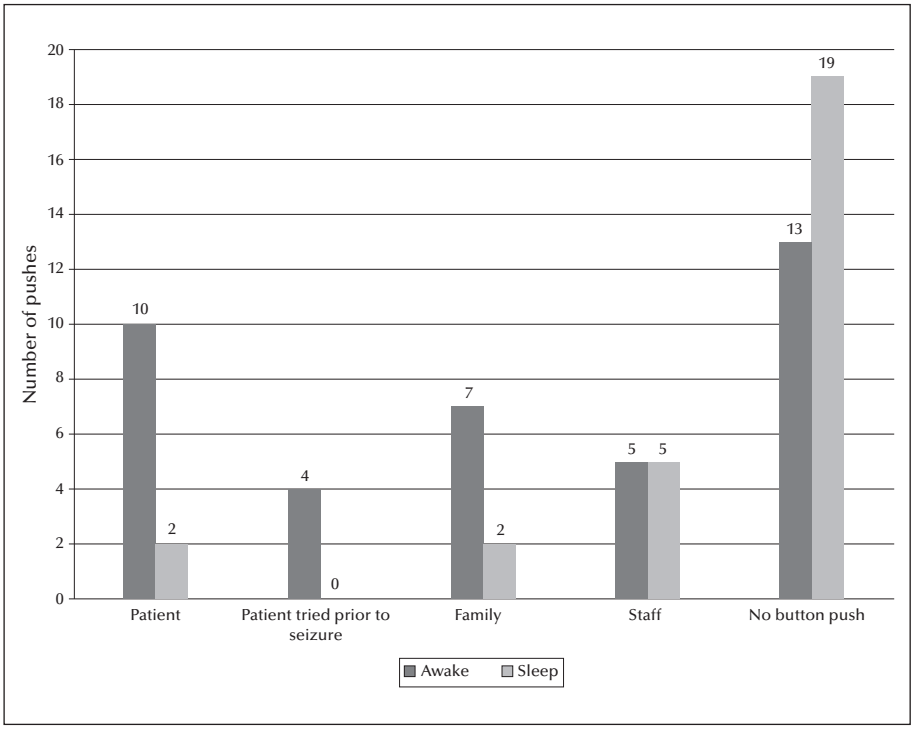

Figure 1. Button pushes for seizures in the awake and sleep state. A higher percentage of push button alerts occurred during the awake state. The infrequency of push button events during sleep highlights the need for close monitoring in the epilepsy monitoring unit for seizures at night.

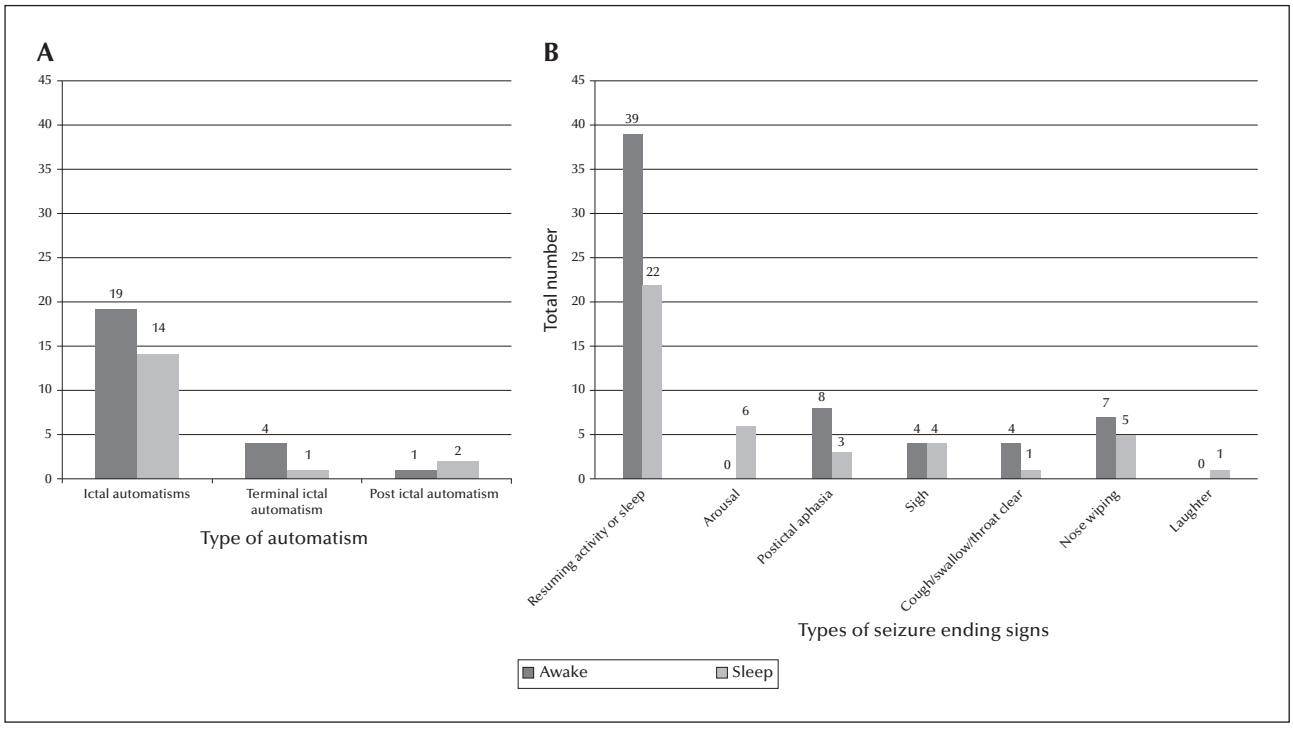

Figure 2. Seizure ending signs and peri-ictal automatisms in seizures during the awake and sleep state. (A) Breakdown of specific seizure ending signs as seen in the subjects reviewed. By far the most common ending sign was a resumption of activity/returning to sleep. (B) Just under half of the patients studied had automatisms during the clinical seizure. Three subgroups of automatisms were found (ictal, terminal ictal and postictal automatisms), as detailed below. Rarely, the end of automatisms coincided with the end of the electrographic seizure or continued after the end of the electrographic seizure.
Ictal automatisms: presence of automatisms that began during a clinical seizure and terminated before the end of the electrographic seizure.
Terminal ictal automatism: automatisms during a clinical seizure that ended at the same time as the end of the electrographic seizure.
Postictal automatism: automatisms beginning during a clinical seizure that persist after the end of an electrographic seizure.

Seizures during sleep

Of the 28 patients who had seizures during sleep, 13 were not examined during their seizure (46.4%). There was a total of nine button pushes during seizures; five by family members, two by staff, and two by patients after the seizure (*figure 1*). Fourteen had ictal automatisms (50%) and 12 patients had automatisms that terminated before cessation of the electrographic seizure. In one patient, the end of automatisms coincided with the end of the electrographic seizure and two patients had persistence of automatisms after the end of the electrographic seizure *(figure 2A)*. No auras were reported. Seven of the 13 unexamined patients went back to sleep after the seizure without any awareness of the event (*video sequence 4*), while the remaining six were aroused from sleep. Of the 15 seizures examined during sleep, all showed an abrupt change in behavioural activity and contact at the end of the clinical seizure. Specific seizure ending signs were seen in 10 patients (35.7%), with a sigh noted in four, nose wiping seen in five, and spontaneous postictal laughter in one patient (*figure 2B*).

Temporal *vs* extra-temporal lobe seizures

Specific ending signs were seen in 23 of 47 temporal lobe seizures (48.9%) and 7 of 20 extra-temporal lobe seizures (35%) (p=0.42) (*figure 2B*). Auras were noted in 10 of 47 temporal lobe seizures (21.3%) and one of 20 seizures (5%) originating outside the temporal lobe (p=0.15).

Examined *vs* unexamined seizures

There was a trend of a higher proportion of unexamined seizures during sleep, compared to those during wakefulness (p=0.06), despite 24-hour staffing in the EMU. Of the nine patients with unexamined seizures during the awake state, only one was aware of their event afterwards. Similarly in sleep, only one of the 13 patients with unexamined seizures during sleep was aware of their events afterwards. Seven of the 13 patients went back to sleep after a seizure and six patients had an arousal. None of the unexamined patients with seizures during wakefulness went to sleep (p=0.02).

Discussion

Clinical evaluation of seizure semiology is an important tool for characterizing the propagation and localizing the onset of seizures (Loddenkemper and Kotagal, 2005; Rossetti and Kaplan, 2010; Stoyke *et al*., 2011). Visualization of the semiology has proven to be more accurate in localization than clinical descriptions of a seizure (Heo *et al*., 2008; Berg *et al*., 2010). Semiological signs seen at the end of a seizure can offer additional localizing value, including findings of postictal aphasia, Todd's paralysis or last clonic jerk (Leutmezer and Baumgartner, 2002; Loddenkemper and Kotagal, 2005). Characterizing the ending of a seizure is important for accurate seizure reporting by the family, which is necessary for the physician in an outpatient setting to gauge effectiveness of therapeutics.

In this study, we characterized seizure ending signs in patients with dyscognitive focal seizures. Seizure ending signs are often subtle and the most common finding is a sudden change in motor activity level and resumption of contact with the environment. This finding, while at times subtle and ill-defined, can be reliably used, particularly in the outpatient setting by families, when there is concern for ongoing seizure activity. The transition from ictal to postictal change in responsiveness might be more distinct than at the onset of a seizure and more reliable in terms of understanding whether a patient is indeed impaired in his/her interaction with the environment and should abstain from certain activities such as driving.

More specific signs such as nose wiping, coughing or throat clearing, or a deep sigh, are seen in around half of patients. This has been postulated to be secondary to an insular and amygdala autonomic mechanism (Devinsky *et al*., 1994; Leutmezer *et al*., 1998; Leutmezer and Baumgartner, 2002; Catenoix *et al*., 2004; Devinsky, 2004; Caicoya and Serratose, 2006), however, in our cohort, these signs were not significantly more frequent in temporal seizures compared to extra-temporal lobe seizures. This suggests that specific signs are more likely a function of propagation of a seizure rather than indicative of the location of onset.

While auras are thought to be more commonly associated with temporal lobe seizures (Kramer *et al*., 1997), in our study, the presence of auras was not statistically significant in patients with temporal lobe seizures *vs* extra-temporal seizures. Auras in frontal lobe seizures are not uncommon, and vary with frequency (18 to 60%) (Saygi *et al*., 1992; Salanova *et al*., 1994; Kramer *et al*., 1997; Kotagal *et al*., 2003). This is likely dependent on the origin of seizure onset and the propagation pattern. It is also possible that the patients are underreporting their auras due to impaired cognition during the seizure.

Automatisms have been commonly recognized as manifestations of focal epilepsy, occurring during or after a clinical seizure (Quesney, 1986; Rasonyi *et al*., 2006). While automatisms terminated before the end of the electrographic seizure in the majority of patients in our study who developed automatisms during a clinical seizure, three patients had automatisms that persisted into the postictal period, making it an unreliable marker of seizure termination.

A higher number of total button pushes and patient-driven button pushes occurred with seizures during wakefulness. This underscores the importance of 24-hour supervision during an EMU admission and the need for increased vigilance at night, when patients are less likely to report their seizures. Highlighting this point, there was a higher proportion of unexamined seizures during sleep, compared to those during wakefulness despite around-the-clock supervision. Furthermore, of the 22 unexamined seizures in our cohort, only two patients were able to notify staff that they had a seizure postictally. In a monitoring unit, dedicated staff should be vigilant for subtle arousals during the sleep state that may represent the only clinical manifestation of a seizure.

In unexamined patients, approximately half of seizures occurring in sleep resulted in patients going back to sleep. This interesting finding may suggest that sleep homeostasis is at least not completely disrupted by seizures, resulting in a high proportion of patients who return to sleep, as opposed to seizures during the awake state which may lead to confusion and subjective report of fatigue, but not to postictal sleep.

There are several limitations to our approach. Foremost, this was a retrospective study in which the authors were not blinded to the EEG data when reviewing the video data. Further prospective studies are needed to validate these findings and its applicability in clinical practice. We acknowledge that our total sample was small and larger studies are needed to corroborate our data. In the future, we hope to compare the consistency of seizure ending signs in an individual patient, particularly over the course of an EMU admission, as medication doses are adjusted.

In conclusion, while specific seizure ending signs are present in some seizures, resumption of contact with the environment is more significantly correlated to the end of a seizure in the awake patient and can be reliably used as a marker of cessation of seizure activity. Specific seizure ending signs are not exclusive to seizures originating from the temporal lobe and may be more suggestive of propagation patterns. Seizures that were not examined were often also not reported

by the patient, emphasizing the necessity for dedicated staff present to monitor patients. Seizure semiology, particularly during the sleep state, can be very subtle and arousals during video monitoring should alert the monitoring staff. In the outpatient setting, patients' accounts and recollection of seizure frequency are unreliable and accounts from family members and bystander reports will give a more accurate representation of the patient's seizure frequency. □

Supplementary data.
Summary didactic slides are available on the www.epilepticdisorders.com website.

Acknowledgements and disclosures.
We confirm that we have read the Journal's position on issues involved in ethical publication and affirm that this report is consistent with those guidelines.
Dr. Schuele has served on the scientific advisory board for Lundbeck Inc., received honoraria from GSK, UCB pharmaceutical and Sunovion for speaker bureau activities, and receives research support from the National Institute of Health (RFA-NS-14-004) and the Danny Did Foundation. Dr. Macken has served on the scientific advisory board and received honoraria from speaker's bureau activities for UCB Pharma and Cyberonics Inc and Sunovion. Dr. Gerard receives research support from the National Institute of Health (U01NS038455). Dr. Gavvala receives salary support from an American Brain Foundation Clinical Research Training Fellowship.

Legends for video sequences

Video sequence 1

A 21-year-old female with left hemispheric focal epilepsy due to malformation of cortical development who had a seizure during wakefulness. At the time, her parents were talking in the background. The seizure is characterized by biting of her lip and clasping of her hands and a lack of interaction with her environment, although she seemed to nod appropriately in response to portions of her parent's conversation. The seizure end is characterized by abrupt return of responsiveness and return of speech. The parents were unaware of the seizure. Afterwards, the patient reported that the onset of seizure was characterized by a feeling of heat over the whole body.

Keywords for the video research on www.epilepticdisorders.com

Etiology: brain malformation (not specified)
Phenomology: absence (dialeptic) seizure; automotor seizure; behavior (altered)
Localization: temporal lobe (left)
Syndrome: focal non-idiopathic temporal (TLE)

Video sequence 2

An 18-year-old female with left temporal lobe epilepsy secondary to a cavernous malformation with a seizure during sleep. Initial EEG seizure is without clinical correlate, however, the patient is later aroused with swallowing movements and hand automatisms. Soon after the end of the electrographic seizure, the patient wipes her nose and returns back to sleep.

Keywords for the video research on www.epilepticdisorders.com

Etiology: brain malformation (not specified)
Phenomology: nocturnal seizure; automotor seizure; nosewiping
Localization: temporal lobe (left)
Syndrome: focal non-idiopathic temporal (TLE)

Video sequence 3

A 57-year-old female with left temporal lobe epilepsy with a seizure occurring during sleep. The seizure starts with restless movements, then hand automatisms, with seizure ending signs of a deep sigh, and then arousal.

Keywords for the video research on www.epilepticdisorders.com

Etiology: brain malformation (not specified)
Phenomology: automotor seizure; postictal signs
Localization: temporal lobe (left)
Syndrome: focal non-idiopathic temporal (TLE)

Video sequence 4

A 30-year-old female with bitemporal lobe epilepsy secondary to autoimmune limbic encephalopathy who had a seizure during sleep. The seizure is characterized by an arousal, eye opening with blinking, neck extension, and what appears to be arm posturing, which is obscured by sheets. At the end of the seizure, the patient returns back to sleep with no awareness of the seizure. The patient had similar seizures during wakefulness, where examination revealed that she was unresponsive.

Keywords for the video research on www.epilepticdisorders.com

Etiology: encephalitis
Phenomology: absence (dialeptic) seizure; postictal signs
Localization: temporal lobe (left)
Syndrome: focal non-idiopathic temporal (TLE)

References

Beniczky SAA, Fogarasi M, Neufeld NB, *et al*. Seizure semiology inferred from clinical descriptions and from video recordings. How accurate are they? *Epilepsy Behav* 2012; 24(2): 213-5.

Berg AT, Berkovic SF, Brodie MJ, *et al*. Revised terminology and concepts for organization of seizures and epilepsies: report of the ILAE Commission on Classification and Terminology, 2005-2009. *Epilepsia* 2010; 51(4): 676-85.

Blume WT, Lüders HO, Mizrahi E, Tassinari C, van Emde Boas W, Engel J. Glossary of descriptive terminology for ictal semiology: report of the ILAE task force on classification and terminology. *Epilepsia* 2001; 42(9): 1212-8.

Caicoya AG, Serratose JM. Postictal behaviour in temporal lobe epilepsy. *Epileptic Disord* 2006; 8(3): 228-31.

Catenoix H, Guenot M, Isnard J, Fischer C, Mauguiere F, Ryvlin P. Intracranial EEG study of seizure-associated nose wiping. *Neurology* 2004; 63(6): 1127-9.

Devinsky O. Effects of seizures on autonomic and cardiovascular function. *Epilepsy Curr* 2004; 4(2): 43-6.

Devinsky O, Kelley K, Yacubian EMT. Postictal behavior: a clinical and subdural electroencephalographic study. *Arch Neurol* 1994; 51: 254-9.

Heo JH, Kim DW, Lee SY, Cho J, Lee SK, Nam H. Reliability of semiology description. *Neurologist* 2008; 14(1): 7-11.

Kotagal P, Arunkumar G, Hammel J, Mascha ED. Complex partial seizures of frontal lobe onset statistical analysis of ictal semiology. *Seizure* 2003; 12(5): 268-81.

Kramer U, Riviello JJ, Carmant L, Black PM, Madsen J, Holmes GL. Clinical characteristics of complex partial seizures: a temporal versus a frontal lobe onset. *Seizure* 1997; 6: 57-61.

Leutmezer F, Baumgartner C. Postictal signs of lateralizing and localizing significance. *Epileptic Disord* 2002; 4: 43-8.

Leutmezer F, Serles W, Lehrner J, Pataraia E, Zeiler K, Baumgartner C. Postictal nose wiping: a lateralizing sign in temporal lobe complex partial seizures. *Neurology* 1998; 51: 1175-7.

Loddenkemper T, Kotagal P. Lateralizing signs during seizures in focal epilepsy. *Epilepsy Behav* 2005; 7(1): 1-17.

Palmini A, Gloor P. The localizing value of auras in partial seizures: a prospective and retrospective study. *Neurology* 1992; 42: 801-8.

Quesney LF. Clinical and EEG features of complex partial seizures of temporal lobe origin. *Epilepsia* 1986; 27(2): S27-45.

Rasonyi G, Fogarasi A, Kelemen A, Janszky J, Halasz P. Lateralizing value of postictal automatisms in temporal lobe epilepsy. *Epilepsy Res* 2006; 70(2-3): 239-43.

Rossetti A, Kaplan P. Seizure semiology: an overview of the "inverse problem". *Eur Neurol* 2010; 63: 3-10.

Salanova V, Quesney LF, Rasmussen T, Andermann F, Olivier A. Reevaluation of surgical failures and the role of reoperation in 39 patients with frontal lobe epilepsy. *Epilepsia* 1994; 35(1): 70-80.

Saygi S, Katz A, Marks DA, Spencer SS. Frontal lobe parital seizures and psychogenic seizures: comparison of clinical and ictal characteristics. *Neurology* 1992; 42: 1274-7.

Stoyke C, Bilgin O, Noachtar S. Video atlas of lateralising and localising seizure phenomena. *Epileptic Disord* 2011; 13(2): 113-24.

Widdess-Walsh P, Kotagal P, Jeha L, Wu G, Burgess R. Multiple auras: clinical significance and pathophysiology. *Neurology* 2007; 69(8): 755-61.

TEST YOURSELF

(1) What is not a commonly described seizure ending sign?
A. Nose wiping
B. Spitting
C. Resumption of contact with the environment
D. Deep sigh

(2) Which of the following is a compelling reason to have vigilant EMU staff at nighttime?
A. Patients are more likely to have a seizure at night
B. Seizures at night can be hard to detect and may consist only of a brief arousal
C. There are fewer physicians around at night
D. EMU staff do not need to closely watch patients because they are likely to push the button for seizures

(3) Which of the following is a true statement regarding seizure ending signs?
A. They are specific to temporal lobe epilepsy
B. The presence of a specific seizure ending sign is always associated with the presence of an aura
C. Seizure ending signs are more commonly seen at night
D. They often are subtle and most commonly are characterized by resumption of activity

Note: Reading the manuscript provides an answer to all questions. Correct answers may be accessed on the website, www.epilepticdisorders.com, under the section "The EpiCentre".