Review

Lateralized Periodic Discharges: Which patterns are interictal, ictal, or peri-ictal?

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HIGHLIGHTS

- Specific criteria are proposed for Lateralized Periodic Discharges (LPDs) to be designated as “ictal/peri-ictal” or interictal/irritative brain injury.
- Identification of peri-ictal LPDs should lead to longer periods of video-EEG monitoring to detect seizure activity.
- LPDs-max, a subtype of LPDs-plus, is a pattern of refractory focal non-convulsive status epilepticus.

A B S T R A C T

There is an ongoing debate if Lateralized Periodic Discharges (LPDs) represent an interictal pattern reflecting non-specific but irritative brain injury, or conversely, is an ictal pattern. The challenge is: how to correctly manage these patients? Between this apparent dichotomous distinction, there is a pattern lying along the interictal-ictal continuum (IIC) that we may call “peri-ictal”. Peri-ictal means that LPDs are temporally associated with epileptic seizures (although not necessarily in the same recording). Their recognition should lead to careful EEG monitoring and longer periods of video-EEG to detect seizure activity (clinical and/or subclinical seizures). In order to distinguish which kind of LPDs should be considered as representing interictal/irritative brain injury versus ictal/per-ictal LPDs, a set of criteria, with both clinical/neuroimaging and EEG, is proposed. Among them, the dichotomy LPDs-proper versus LPDs-plus should be retained. Spiky or sharp LPDs followed by associated slow after-waves or periods of flattening giving rise to a triphasic morphology should be included in the definition of LPDs-plus. We propose defining a particular subtype of LPDs-plus that we call “LPDs-max”. The LPDs-max pattern corresponds to an ictal pattern, and therefore, a focal non-convulsive status epilepticus, sometimes associated with subtle motor signs and epileptic seizures. LPDs-max include periodic polyspike-wave activity and/or focal burst-suppression-like patterns. LPDs-max have a posterior predominance over the tempo-parieto-occipital regions and are refractory to antiseizure drugs. Interpretations of EEGs in critically ill patients require a global clinical approach, not limited to the EEG patterns. The clinical context and results of neuroimaging play key roles.

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1. Introduction

Chatrian et al. proposed the name of Periodic Lateralized Epileptiform Discharges (PLEDs) to describe paroxysmal sharp waves repeating periodically or quasiperiodically separated by periods of apparent quiescence at a rate of about 1 Hz (Chatrian et al., 1964). In their series, 29 of 33 patients had clinical seizures, including seven patients with epilepsy partialis continua. Subsequent publications led to some confusion. Indeed, PLEDs were seen in focal brain injuries (cerebral abscess, encephalitis, cerebral hemorrhage or infarction, trauma, non-ketotic hyperglycemia) or were characterized as an ictal pattern (Lin and Drislane, 2018). As epileptiform was an ambiguous term, the American Clinical Neurophysiology Society (ACNS) exchanged PLEDs for Lateralized Periodic Discharges (LPDs), leaving out the modifier epileptiform (Hirsch et al., 2013).

LPDs are a common pattern observed in critically ill. Their interpretation may present challenges. Are LPDs an interictal pattern or an ictal pattern, and hence are diagnostic of a focal status epilepticus (SE)? Between this dichotomous distinction (interictal versus ictal), we think there is a particular pattern along the interictal-ictal continuum (IIC) that we can call “peri-ictal”. Peri-ictal refers to the concept that LPDs are associated with seizures and that the recognition of these LPDs should lead to longer periods of video-EEG monitoring to detect seizure activity. Peri-ictal LPDs probably warrant changes in antiseizure drug (ASD) treatment to stop seizures and to avoid SE with its associated, additional morbidity. In this article, we propose criteria that distinguish which kind of LPDs should be considered as representing interictal/irritative brain injury versus peri-ictal/ictal LPDs (Table 1). This distinction is crucial in order to prioritize and optimize treatment.

2. Methods

The present study is a narrative review enriched with reports from personal cases. All cases presented in this article were hospitalized at the University Hospital of Montpellier, France.

3. Interictal-ictal continuum

The concept of IIC was initially proposed for LPDs (Pohlmann-Eden et al., 1996) but has been extended to other periodic or rhythmic EEG patterns. A consensus definition has been recently proposed and includes any periodic or spike-wave pattern that averages > 1.0 and ≤ 2.5 Hz over 10 seconds, any periodic or spike-wave pattern that averages ≥ 0.5 Hz and ≤ 1.0 Hz over 10 seconds and has a “plus” modifier or fluctuation (see below for the definition of “plus” modifier) (Hirsch et al., 2021).

4. LPDs-proper versus LPDs-plus

Reiher et al. classified PLEDs into PLEDs-proper (PLEDs without rhythmic discharges) and PLEDs-plus (PLEDs with rhythmic discharges). Rhythmic discharges were defined “as any brief focal stereotyped rhythmic discharge closely associated in time and in spatial distribution to a higher amplitude interictal epileptiform discharge” (Reiher et al., 1991). The suffix “plus” is not limited to LPDs. According to the ACNS: “Plus” is an “additional feature which renders the pattern more ictal-appearing than the usual term without the plus” (Hirsch et al., 2013) and defined LPDs-plus as “periodic discharges with superimposed fast activity, superimposed rhythmic activity, superimposed sharp waves or spikes, and/or having triphasic morphology” (Lin and Drislane, 2018).

LPDs-plus are associated with fast “epileptic” rhythms, spikes, or polyspikes inside the complexes (Fig. 1). With these elements, the distinction between “proper” versus “plus” is easy, but sometimes the distinction is subjective when the LPDs have only a spiky morphology. Sharp LPDs have a higher association with epileptic seizures than LPDs with a blunt delta pattern (Husari and Johnson, 2020). “Most spike or sharp wave discharges of clinical import are followed by a slow wave or series of slow deflections” (Maudsley, 1971). Spiky LPDs followed by an associated slow after-waves or periods of flattening (see below), giving rise to a triphasic morphology should be included in the definition of LPDs-plus (Fig. 2; Supplementary Figs. 4–6).

Despite the limitations in the classification of LPDs, this dichotomy “proper” versus “plus” must be retained when interpreting EEGs in critically ill patients. LPDs-plus are more often associated with clinical seizures than LPDs-proper (Husari and Johnson, 2020, Lin and Drislane, 2018, Newey et al., 2017, Rubinos et al., 2020).
Seizures and SE were observed in 74% of the patients with LPDs-plus versus 6% with LPDs-proper (Reiher et al., 1991). More recently, in a large group of critically ill adult patients undergoing continuous EEG monitoring, LPDs were more likely to be associated with seizures in patients with LPDs-plus compared with LPDs alone (Rodriguez Ruiz et al., 2017). The presence of LPDs-plus represents a strong element for a peri-ictal or a frankly ictal activity.

5. LPDs-max: a singular subtype of LPDs-plus

5.1. Periodic polyspike-wave activity

Beaumanoir described a peculiar periodic lateralized pattern characterized by a lack of response to benzodiazepines (BZP) that she called Periodic Sinusoid Paroxymal Activity (PSPA) (Beaumanoir, 1985). A more complete description was given in a series of 11 adult patients with vascular risk factors (two severe carotid stenoses, two transient cerebral ischemic attacks, three cerebral ischemic insults, and four cases with general cerebral hypoperfusion) (Beaumanoir et al., 1996). This pattern consisted of brief, sinusoid waves with a frequency at about 7–9 Hz, with positive and negative phases of the same amplitude. The bursts were usually followed by a slow wave, and the periodicity did not exceed two seconds. This pattern was mainly seen over both temporo-parieto-occipital regions, with amplitude asymmetry, and was always associated with a confusional state, along with some minor motor signs in some patients. The patients were considered as having SE; BZP injection did not affect the pattern. PSPAs were recorded over several hours or days. Mental confusion disappeared with the activity, curiously, suddenly after mobilization of the head in four cases. If the activity disappeared gradually, PSPA patterns could be replaced by “classical” LPDs.

PSPA was similar to the LPDs-plus described by Reiher et al., but in the series of Beaumanoir et al. was regarded as a refractory form of focal non-convulsive status epilepticus (NCSE). More simply, we refer to this activity Periodic PolySpike-Wave Activity (PPSWA) (Fig. 1).

5.2. Focal burst-suppression pattern/Post-LPDs flattening

Burst-suppression patterns are characterized by periods of high-voltage electrical activity alternating with periods of suppression (below 10 $\mu$V) (Kane et al., 2017) with 50% to 99% of the record consisting of suppression (Hirsch et al., 2021). Bursts are generalized but may be bilaterally asynchronous or unilateral (Stern, 2013). This pattern may be observed in various situations with epilepsy, including severe encephalopathies of infancy, different metabolic disorders (Bureau et al., 2019), and during NREM sleep of patients with infantile spasms and Lennox-Gastaut syndrome (Pedley et al., 2003). Burst-suppression patterns may also be observed in the end-stages of generalized convulsive SE (Treiman et al., 1990).

In severe head trauma, focal burst-suppression patterns may reflect focal ischemia or edema (Stockard et al., 1975). Focal burst-suppression patterns on intra-operative electrocorticography have been reported in patients with temporal lobe epilepsy surgery (Cendes et al., 1996, Hosain et al., 1995, Xu et al., 2020).
In focal epilepsies with onset before the age of 10 years, the observation of periods of flattening just after the interictal abnormalities that may give rise to electrical silences during sleep was associated with drug-resistance and poor outcome (Bureau and Maton, 1998). Finally, burst-suppression patterns can end focal seizures (Blume et al., 2010).

Regardless of the etiologies, burst-suppression patterns are associated with severe conditions. LPDs that occur according to a model characterized by bursts alternating with nearly flat patterns of focal burst-suppression correspond in the majority of the cases to an ictal pattern and, therefore, to a focal SE (Figs. 3–5; Supplementary Figs. 6–15). To a lesser degree, the presence of focal flattening after each LPDs represents an increased likelihood of the appearance of seizures and may direct EEGers to pay more attention to the possibility of a peri-ictal pattern.

5.3. Definition of LPDs-max

LPDs-max represent a peculiar subtype of LPDs-plus corresponding in all cases to an ictal pattern. LPDs-max includes PPSWA and/or focal burst-suppression-like patterns. These two patterns may be associated with each other. The periodicity is short at about 1 Hz (see below). LPDs-max may be associated, or not, with subtle motor signs and epileptic seizures, whether clinical or subclinical (Supplementary Figs. 6 and 7). This activity is often found at the tempo-parieto-occipital regions (Beaumanoir et al., 1996, Terzano et al., 1986) (Figs. 2–5). The frontal lobes seem to be spared. LPDs-max are typically refractory to BZP (Beaumanoir et al., 1996) but also to other antiseizure drugs (Figs. 2–5) and can persist despite general anesthesia with burst-suppression patterns induced by thiopental or propofol (Supplementary Fig. 11).

6. Periodicity of the LPDs

Periodic activities are defined by their periodicity and classically, a short versus long period > 4 seconds (Gaches, 1971). This distinction may follow etiologic underpinnings. LPDs with long periods may be observed with brain tumors, brain abscesses, subdural hematoma, parasitic diseases, while LPDs with short periods may be observed in case of cerebral infarctions, herpes simplex virus (HSV) encephalitis (Dunand and Jallon, 2002). This classification was proposed before the widespread use of neuroimaging procedures and did not provide information as to whether LPDs were ictal, interictal, or lay along the IIC.

An epileptic seizure is a rhythmic activity, and by definition, SE is a rhythmic phenomenon, whatever the morphology of the paroxysms. A periodic activity is more challenging, but the shorter the period, the higher the LPDs are likely to be ictal or peri-ictal. Positron Emission Tomography (PET) with 18fluorodeoxyglucose (FDG) studies the glucose metabolism, which is an indicator of neuronal activity. The association between LPDs and hypermetabolism was investigated retrospectively in nine patients who underwent FDG PET. Subramaniam et al. (2019).

In a large group of critically
Fig. 3. Top: Ictal Lateralized Periodic Discharges (LPDs). 62-year-old woman with a history of chronic alcohol abuse. Several generalized tonic-clonic seizures in the context of alcohol withdrawal. Hospitalization for jargon aphasia. Right hemianopsia on clinical examination. Inset shows left pulvinar hyperintensity and left occipital hypersignal. Burst of polyspike-waves over the temporo-parieto-occipital region occurring every 1 to 1.5 seconds with periods of flattening between the LPDs (burst-suppression pattern). In this case, the LPDs can be considered as LPDs-max. Faulty ECG electrodes. During the EEG, one subclinical focal left occipital seizure was recorded (Supplementary Fig. 7). Subacute encephalopathy with seizures in chronic alcoholics (SESA syndrome) was diagnosed. Status epilepticus was refractory to antiseizure drugs. Progressively, the LPDs became less frequent and less sharp.

Bottom: EEG performed 11 days after the first EEG. The patient was no longer aphasic. Eyes closed; the background activity is better on the right hemisphere. LPDs with predominance over the left parieto-occipital region at a frequency rate of about 3–3.5 s. There is a small spike within the complexes. There is also a slight variation in the periodicity, but as the clinical symptoms have resolved, these LPDs can be classified as inter-ictal.
ill adult patients undergoing continuous EEG monitoring, LPDs were associated with seizures at any frequency but seizure risk increased with higher frequencies regardless of the plus modifier (Rodriguez Ruiz et al., 2017).

LPDs with time-locked contralateral symptoms are clearly ictal, regardless of the frequency of the pattern. Among, ten patients with a clear time-locked clinical correlation (motor symptoms in nine cases, stereotyped sensory symptoms in one), the frequency of the period was ≤0.5 Hz in 50% of the patients and ≥1 Hz in the 50% remaining (Sen-Gupta et al., 2014).

We propose LPDs with a periodicity greater than 1 Hz are associated with ictal or peri-ictal patterns, whereas a periodicity of 0.5 Hz or less is associated with interictal/irritative brain injury. Between 0.5 and 1 Hz, the plus modifier, the spatiotemporal evolution of the pattern can make the difference. Time-locked symptoms to the LPDs can be considered a strictly sufficient criterion to determine the ictal nature, regardless of the periodicity and other criteria.

7. Spatiotemporal evolution of the pattern

Epileptic seizures, and therefore SE are dynamic processes with evolution of the ictal pattern, e.g., a change in repetition rate, in morphology, and spread of the ictal discharge to other anatomical regions (Sutter and Kaplan, 2012). A consensus panel of experts proposed particular working criteria for the EEG diagnosis of NCSE (Salzburg Consensus Criteria for NCSE) (Beniczky et al., 2013, Leitinger et al., 2015). The typical spatiotemporal evolution of the pattern (change in voltage/morphology, in frequency, and location) is one of the criteria for the diagnosis of NCSE.

The dynamical evolution of the pattern argues in favor of ictal/peri-ictal LPDs. Among 100 cases with continuous-EEG, LPDs with loss of interdischarge interval lasting ≥1 second with or without overlying faster frequencies were significantly higher risk of developing seizure and/or SE followed by LPDs with overlying faster frequencies and then sharply contoured morphology (Newey et al., 2017). The spatiotemporal evolution of the pattern includes LPDs occurring with variable intervals, changes in amplitude/morphology, and the propagation of the pattern to another brain area (Figs. 4, 6, 7; Supplementary Fig. 4).

8. Neurological signs and seizure disorders

When epileptic seizures are observed by the health care team or recorded during the EEG, LPDs may be considered above all as peri-ictal or ictal. Focal neurological deficits such as hemianopsia, aphasia (Figs. 2, 3; Supplementary Figs. 6, 7, 12, 13), and motor deficits not explained by a structural brain lesion argue for a peri-ictal/ictal patterns (Supplementary Fig. 14). When LPDs are observed in confused patients, LPDs may represent an ictal pattern (Beaumanoir et al., 1996, Terzano et al., 1986) (Fig. 4; Supplementary Fig. 15). Mental confusion corresponds to an impairment in or loss of awareness of the position of the self in relation to place, time, situation, or other persons (WHO, 2020) and can evolve to a stuporous state. Mental confusion must be clearly differentiated from an impairment of alertness, commonly seen for example, in patients with large strokes.

Ictal LPDs may be associated with subtle seizures, e.g., LPDs followed by nystagmus retractorius (Young et al., 1977), gaze deviation (Kaplan, 2005), subjective focal sensations time-locked to
the LPDs (Sen-Gupta et al., 2011), epilepsy partialis continua (Thomas et al., 1977). In epilepsy partialis continua, the symptoms are or not time-locked to the periodic activity (Fig. 8). As mentioned previously, time-locked symptoms to the periodic EEG activity may be seen with a frequencies of ≤0.5 Hz (Sen-Gupta et al., 2014). Time-locked symptoms are a sufficient criterion to determine the ictal nature of the LPDs, regardless of the other criteria.

9. Neuroimaging procedures

Single-photon emission computed tomography (SPECT) or PET scan have been proposed for the evaluation of patients suspected of having focal NCSE (Dong et al., 2009, Jaraba et al., 2019, Siclari et al., 2013) and in patients with LPDs (Lin and Drislane, 2018) (Fig. 2), but these procedures require specialized units and may be impractical for patients with acute neurological conditions. It
appears challenging to implement on a large-scale uniform, simple and rapid procedures, such as perfusion-MRI or -CT.

Up to half of patients with SE have signal changes on T2/FLAIR and diffusion-weighted images (DWI) (Requena et al., 2019). DWI is a key imaging technique, with a hypersignal corresponding to vasogenic edema but also sometimes to cytotoxicity, with a restriction of the apparent diffusion coefficient. MRI may show signal changes of the cerebral cortex not corresponding to a specific vascular territory, the pulvinar nucleus of the thalamus ipsilateral to the epileptiform activity (Fig. 3, Supplementary Figs. 7, 10) and, more rarely, in the contralateral cerebellum (crossed cerebellar diaschisis) (Sarria-Estrada and Toledo, 2019). A leptomeningeal contrast-enhancement may sometimes be seen. MR-angiography may show angiographic patterns known as “luxury perfusion” (Sarria-Estrada and Toledo, 2019). Susceptibility-weighted imaging can show focally diminished cortical veins in hyperperfused ictal regions (Aellen et al., 2014). The Arterial Spin Labeling (ASL) technique without a contrast injection appears to be a promising technique in the field of perfusion and epilepsy. This technique is very sensitive to variations in cerebral blood flow (CBF), with, in the case of seizures, high CBF in the cortical epileptogenic zone, the ipsilateral pulvinar, and the contralateral cerebellum (Schertz et al., 2020).

A major challenge with these MRI findings is that we do not know how long the signal change persists after the cessation of SE. Some patients may develop permanent brain damage. The exact timing of the disappearance is not presently known, but perfusion normalizes from seconds to minutes after the end of the episode, whereas signal changes on DWI and T2/FLAIR may require up to several weeks to resolve (Sarria-Estrada and Toledo, 2019). In patients with LPDs, MRI findings such as an increased signal in the pulvinar and/or hyperperfusion on perfusion MRI (Szabo et al., 2005) might suggest that the pattern lies along the IIC or potentially ictal. In light of day and night availability of MRI in most hospitals, the possibility of serial MRIs, and the anticipated improvement of the procedure, MRI can become a powerful tool in the management of NCSE. In the future, new criteria, including MRI and other neuroimaging techniques such as perfusion CT, should be used for diagnosing and confirming SE and added to the accepted criteria, especially for controversial patterns such as LPDs (Gélisse et al., 2021).

In patients with focal seizures, perfusion CT may show regional hyperperfusion, whereas hypoperfusion may be due to a post-ictal state (Strambo et al., 2018). The limitation of this procedure is the short time of acquisition of less than 1 minute, and patients may be free of seizure during this period (Bargalló et al., 2019). More extensive experience is required for patients with LPDs only. Gugger et al. reported one patient not only with LPDs and cortical hyperperfusion but also with contralateral periodic jerking. In the future, the use of perfusion CT in patients with periodic discharges could probably help determine where a patient lies on the IIC (Gugger et al., 2020).

10. Criteria not included

10.1. Amplitude of the LPDs

LPDs are a transient pattern that progressively resolves, with decreases in amplitude and repetition rate over several weeks (Zumsteg et al., 2004) (Fig. 3, Supplementary Figs. 7 and 13). High-amplitude LPDs probably represent an index of epileptogenicity, but only if the LPDs are sharp. In a retrospective series of 100 consecutive patients, LPDs with a blunt delta pattern had the lowest risk for
seizures (Newey et al., 2017). Conversely, low- or medium-amplitude LPDs may correspond to a peri-ictal pattern (Figs. 6, 7) or even an ictal pattern (Beaumanoir et al., 1996). Medium- and high-amplitude LPDs may also be observed in inter-ictal/irritative brain injuries such as HSV encephalitis (Supplementary Fig. 1) and viral non-HSV encephalitis (Gélisse et al., 2019).

Fig. 8. A: 58-year-old woman. Right middle cerebral artery stroke five months earlier. Lateralized Periodic Discharges (LPDs) over the right hemisphere at about 1 Hz. There are spikes within the complexes suggesting LPDs-plus. Independently, there are clonic movements of the left hand (EMG) corresponding to an epilepsia partialis continua. Inset shows the FLAIR MRI of the patient with sequelae of a right middle artery infarct. B: 67-year-old woman. Clonic jerks on the left side of the face and left hemiparesis. LPDs over the right hemisphere with predominance over the right fronto-central region corresponding to LPDs-plus. Indeed, the LPDs are sharp, and there are spikes. The periodicity is about 1 Hz. On the EMG (L Face), recording of clonic jerks on the left cheek that are time-locked to the LPDs corresponding to an epilepsia partialis continua. At O1, electrode contact artifact. Inset shows FLAIR MRI of the patient with right temporal cavernous malformation.
10.2. Duration of the LPDs

As shown by the different figures presented in this article and the annex, the duration of the complexes is highly variable, both in interictal and peri-ictal/ictal patterns.

10.3. Effects of intravenous administration of benzodiazepines

Intravenous administration of BZP with both improvement of the clinical state and the EEG is a strong argument in favor of NCSE. However, the effect on the EEG is often imperfectly understood, especially in patients with generalized periodic discharges (GPDs) with trichiphasic morphology (Kaplan et al., 2021) and in patients with Creutzfeld-Jakob disease (CJD) (Gélisse et al., 2019). In these situations, following the IV administration of BZP, there is an apparent improvement in the EEG, but without improvement in behavior, the patients fall asleep. The regression of the trichiphasic waves and the sharp complexes on the EEG results from sleep induction and not from a direct effect of the drug per se, on the EEG pattern. In hepatic encephalopathy, trichiphasic waves (TW) resolve with sleep (Baldy-Moulinier et al., 1981, Kurtz et al., 1972, Niedermeyer, 1999), as well as in other encephalopathies with TWs (Boulanger et al., 2006). In CJD, the periodic sharp wave complexes tend to disappear during spontaneous sleep (Terzano et al., 1995, Wieser et al., 2006).

LPDs may be seen with various etiologies, including cerebral infarctions or bleeds, brain abscesses, brain tumors, subarachnoid hemorrhages, trauma, encephalitis. For each of these situations, it would be necessary to know precisely the influence of natural sleep on the LPDs before considering a diagnostic test. In the acute stage, there is usually an impairment in alertness linked to the neurological injury and/or to other intercurrent medical conditions, e.g., metabolic disorders, pneumonia. In such situations, it may be difficult to see an improvement in the level of consciousness. IV BZP administration may be dangerous in some patients, especially for elderly people, because of respiratory suppression or hypotension, and precautions must be taken. The classification we propose allows the differentiation of interictal/irritative brain injury versus peri-ictal/ictal LPDs and avoid administration of BZP if not necessary.

In the case of ictal patterns, IV BZP administration may be offered and may be useful with regression of the LPDs and improvement in the level of consciousness (Terzano et al., 1985). LPD-max are easy to recognize. IV BZP administration in these situations must be considered as a treatment and not as a diagnostic test. But, the absence of effect does not necessarily mean that it is not a SE (Figs. 2-5; Supplementary Figs. 6–11, 13). In the opinion of Beaumanoir et al. their ictal patterns are usually not difficult to recognize, e.g., LPDs detect seizure activity and eventually to adjust ASDs. On the other hand, ictal patterns are usually not difficult to recognize, e.g., LPDs with time-locked symptoms and LPDs-max. LPDs-max may be associated, or not, with subtle motor signs and epileptic seizures. They may be regarded as a refractory form of focal NCSE involving the tempo-parieto-occipital region.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.clinph.2021.04.003.

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11. Conclusions

Interpretations of EEGs in critically ill patients require a global clinical approach, one not limited to the EEG patterns but including clinical features, and now, the results of cerebral imaging. EEG patterns that lie on the IIC represent a challenge in terms of care and treatment. The concept of peri-ictal LPDs allows us to determine which patients need careful monitoring and continuous EEG to detect seizure activity and eventually to adjust ASDs. On the other hand, ictal patterns are usually not difficult to recognize, e.g., LPDs with time-locked symptoms and LPDs-max. LPDs-max may be associated, or not, with subtle motor signs and epileptic seizures. They may be regarded as a refractory form of focal NCSE involving the tempo-parieto-occipital region.
