Clinical commentary

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EEG features of nonconvulsive status epilepticus

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ABSTRACT – Nonconvulsive status epilepticus (NCSE) is diagnosed in practice as an enduring epileptic condition with reduced or altered consciousness, but without major convulsive movements, and epileptiform discharges on EEG. In this article, an illustrative and paradigmatic case is presented with a focus on the main EEG features which should be considered when there is clinical suspicion of NCSE. Some clinical and neurophysiological tips are also provided in order to effectively differentiate between NCSE and other conditions. The clinical suspicion of NCSE may be supported by EEG recordings showing rhythmic and dynamic epileptiform activity. However, although a definitive diagnosis of NCSE cannot be made without EEG-based evidence, the "ultimate diagnosis" of NCSE relies on both neurophysiological and clinical features.

Key words: diagnostic criteria, EEG, nonconvulsive status epilepticus

Nonconvulsive status epilepticus (NCSE) is diagnosed in practice as an enduring epileptic condition with reduced or altered consciousness, but without major convulsive movements (Drislane, 2000), and with epileptiform discharges on EEG (Bauer and Trinka, 2010).

Recently, Bauer and Trinka (2010) proposed a distinction between NCSE proper and comatose NCSE on the basis of EEG features and the clinical level of impairment of consciousness (mild in the former and severe in the latter). On the basis of such a distinction (Brigo, 2011), this article focuses on the main EEG features of NCSE proper and provides some clinical and neurophysiological tips in order to better differentiate this condition from comatose NCSE. Together with a review of the most relevant literature on the topic, I present and discuss an illustrative, paradigmatic case.

Case study

Clinical description

An 85-year-old woman was admitted to our emergency department because of a confusional state and reduced reactivity to external stimuli, lasting for several hours. No posturing, automatisms, rotation, or clonic movements were observed. A trial flutter and hypertension were of note, based on previous medical history. She was treated with warfarin and benzodiazepines. During the EEG recording, the patient was alert and very quiet, but

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was confused and disorientated to time, place and situation, unable to recognise familiar people and remember their name, or perform simple tasks.
EEG showed continuous, rhythmic, generalised spike-and-wave discharges, with marked variable frequency (slower and faster components) and some topographic variability (*figures 1A and B*). A rhythmic pattern of this kind strongly pointed to a dynamic process, suggesting an epileptic nature of the event. In this patient, the EEG diagnosis of NCSE was confirmed both clinically and neurophysiologically by electroclinical improvement following intravenous AED administration; the patient gradually improved (she was progressively able to correctly answer questions and perform simple tasks) until full recovery. At the same time, a progressive attenuation (*figure 1C*), up to disappearance (*figure 1D*), of epileptiform discharges was observed.

Discussion

The case presented shows an EEG with typical epileptiform activity of NCSE. An overview of the EEG features which characterise NCSE is further provided, as well as a critical review of the literature.

Which EEG features should be considered?

For an EEG suggestive of status epilepticus (of relevant length and with a compatible clinical picture), careful and precise description of slow waveforms, morphology of epileptiform abnormalities, spatial and temporal distribution, and regularity of the discharge (Gelisse *et al*., 2009) should always be performed. Furthermore, particular attention should be paid to the following EEG features:

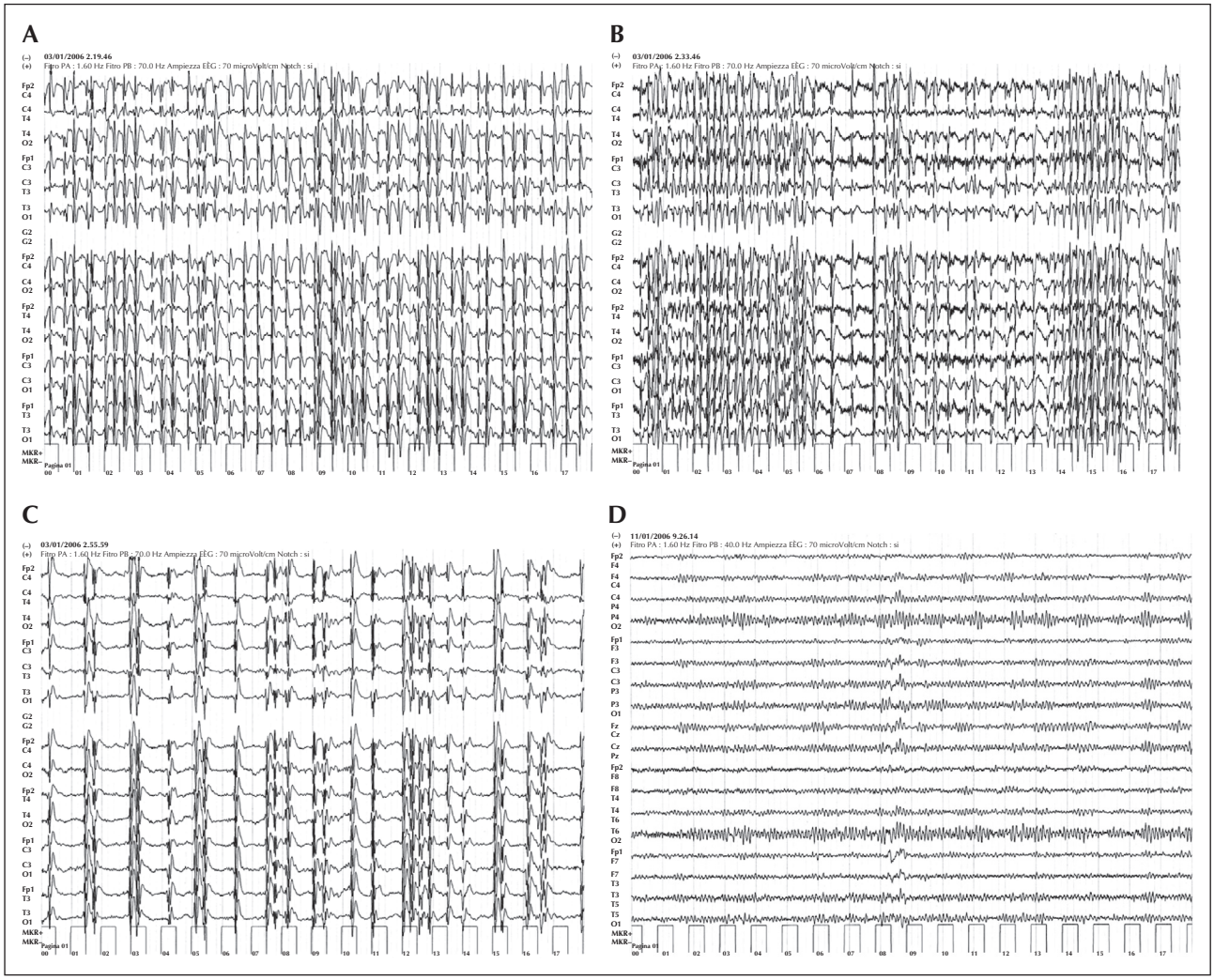

Figure 1. (A, B) Continuous, rhythmic, generalised spike-and-wave discharges, with evident variability of frequency (some slower or faster components) and some topographic variability. (C) Progressive attenuation of epileptiform activity. (D) Disappearance of epileptiform activity.

Rhythmic or periodic EEG pattern
A rhythmic activity is characterised by EEG graphoelements which repeat in a continuous and regular fashion, with a time interval equivalent to the duration of the wave (*i.e.* without any separation between different graphoelements [Gelisse *et al.*, 2009]). On the other hand, periodic activity is characterised by EEG graphoelements which repeat in a discontinuous fashion and are separated by a constant (or almost constant) time interval, longer than the duration of each wave (Gelisse *et al.*, 2009). Periodic activity is considered as a static pattern with only minor variable (<50%) features (morphology, duration, amplitude, and frequency [Kaplan, 2007]). In contrast to periodic activity, rhythmic activity is one of the main EEG features suggestive of ictal epileptic activity. The epileptic significance of periodic epileptiform discharges is questionable since periodic patterns have a different intrinsic epileptic potential, being part of the so-called "ictal-interictal-injury continuum" (Pohlmann-Eden *et al.*, 1996; Chong and Hirsch, 2005; Bauer and Trinka, 2010). Periodic discharges are seen in a wide variety of conditions with different aetiologies, and the discharges themselves are electrographically heterogeneous. Based on this broad spectrum, the association of possible neuronal injury with each type of discharge should be considered in a given clinical setting (Chong and Hirsch, 2005).
From a very practical point of view, the pathological significance of periodic epileptiform discharges depends on the clinical context (aetiology), the observed clinical semiology, the EEG morphology (association with epileptic features and fast rhythm), and the periodicity (Navarro *et al.*, 2009). When there is doubt, intravenous administration of AEDs may be useful (Navarro *et al.*, 2009) (*see point 3*).

Dynamic EEG pattern
Patterns with clearly dynamic features strongly point to an underlying dynamic process, thus suggesting an epileptic nature of the event (such dynamic features of ictal pattern are outlined in all diagnostic descriptions of NCSE available in the literature) (Young *et al.*, 1996; Chong and Hirsch, 2005; Kaplan, 2007). These dynamic EEG features may be useful to differentiate between "true" ictal activity and static, non-dynamic EEG patterns which may occur in structural encephalopathies, as epiphenomena of severe and sometimes irreversible cerebral damage. It is also of note to consider that the most important EEG criterion to differentiate between true ictal patterns and other epileptiform EEG patterns is the presence of dynamic features (evolution of frequency, distribution, and morphology). The only unusual EEG pattern which sometimes may show a certain degree of evolution, especially in the initial phase, is subclinical rhythmic epileptiform discharge of adults (SREDA). Although SREDA may resemble epileptiform activity, and is therefore likely to be misinterpreted as a true epileptiform pattern (Brigo *et al.*, 2010; Brigo, 2012), the main feature discerning SREDA from NCSE is the lack of a clinical correlate rather than the lack of EEG evolution.

EEG changes after AED administration
A clear improvement based on EEG following AED treatment supports the diagnosis of epileptic ictal activity. However, an improvement alone on EEG does not necessarily prove that the discharges are ictal and responsible for the patient's impairment of consciousness (Brenner, 2002; Brigo and Storti, 2011). Therefore, rather than considering only EEG changes after intravenous benzodiazepine or AED administration, a global electroclinical response should be considered.

Conclusion

This case clearly shows that the clinical suspicion of NCSE may be indicated by EEG alone, with rhythmic, dynamic epileptiform activity. Based only on EEG features, it is possible to rule out the presence of epileptiform activity as an epiphenomenon of severe and "static" cerebral damage (Bauer and Trinka, 2010), based on the presence of such rhythmic, dynamic activity. When the EEG is interpreted in a clinical context, the presence of clear electroclinical improvement following AED treatment nevertheless points to the diagnosis of status epilepticus.
In conclusion, NCSE proper cannot be definitively diagnosed without EEG recordings and the "ultimate diagnosis" of NCSE proper relies on both neurophysiological and clinical features. □

Disclosures.
The author has no conflict of interests to disclose.

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