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EEG findings and outcomes of continuous video-EEG monitoring started prior to initiation of seizure treatment in the perinatal stroke

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ABSTRACT

Background: To analyze the findings in the background EEG activity of infants who suffered perinatal stroke.
Methods: Eleven neonates born 2009–2014 diagnosed of ischemic stroke by MRI (three of them with multi-stroke) underwent continuous video-EEG monitoring. Visual and spectral (power spectrum and coherence) analyses of the background EEG was performed in three moments: 1) Onset of EEG recording (prior to initiate seizure treatment), 2) Post-ictal epoch (1–2 h after the last seizure), and 3) one–two days after seizure control. All children aged 2–6 years underwent neurodevelopmental assessment.
Results: Discontinuity, asymmetry, asynchrony, transients, and relative power spectrum in δ and θ frequency bands increased significantly ($p < 0.05$) in the post-ictal epoch with respect to onset of EEG recording. After seizure control, discontinuity, asynchrony, and θ power spectrum no longer had significant differences with those found at onset of EEG recording. Significant differences between the ischemic and unaffected hemispheres were found in transients and in β coherence ($p = 0.002$; $p = 0.001$, respectively) exclusively in the post-ictal epoch. Seizure burden and time-to-control ranged 5–38 min and 0.5–40 h respectively. Currently, only one child is affected by spastic monoparesis. The intelligence quotients ranged 96–123.
Conclusions: The background EEG can undergo significant changes in the post-ictal epoch due to the seizure activity triggered by the perinatal stroke. Most of these EEG changes involve all brain activity and not exclusively the ischemic hemisphere. Many of these modifications in the EEG background reverse following the seizure control. Video-EEG monitoring allows accurate/immediate diagnosis and rapid/intensive treatment of the stroke-associated seizures.

1. Introduction

The clinical symptoms of perinatal stroke are almost exclusively neonatal seizures in the early neonatal period [1,2]. Although seizures are a consequence of the underlying brain injury, seizure activity may contribute to increasing the dimensions of the ischemic lesion. Sustained seizure activity impairs brain development and increases risk for subsequent epilepsy [3,4].

Few studies describe the findings and abnormalities of the background EEG with accurate and objective measurements in the acute period of perinatal ischemic stroke. The aEEG has been used to obtain additional information [5,6], however, it presents multiple limitations in neonatal brain monitoring [7].

To date, only one conventional video-EEG study [8], and some case reports [9,10] describe the characteristics of epileptiform discharges and some interictal EEG findings. However, neither the exact moment nor the objective abnormalities of the background EEG have been well defined, and therefore, can be somewhat confusing.

We hypothesize that in addition to the focal ischemic lesion, an excessive seizure burden would produce significant modifications in the

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[1] https://viinv.ull.es/grupos/1150/.
[2] GINDe < http://ginde.webs.ull.es/ > .

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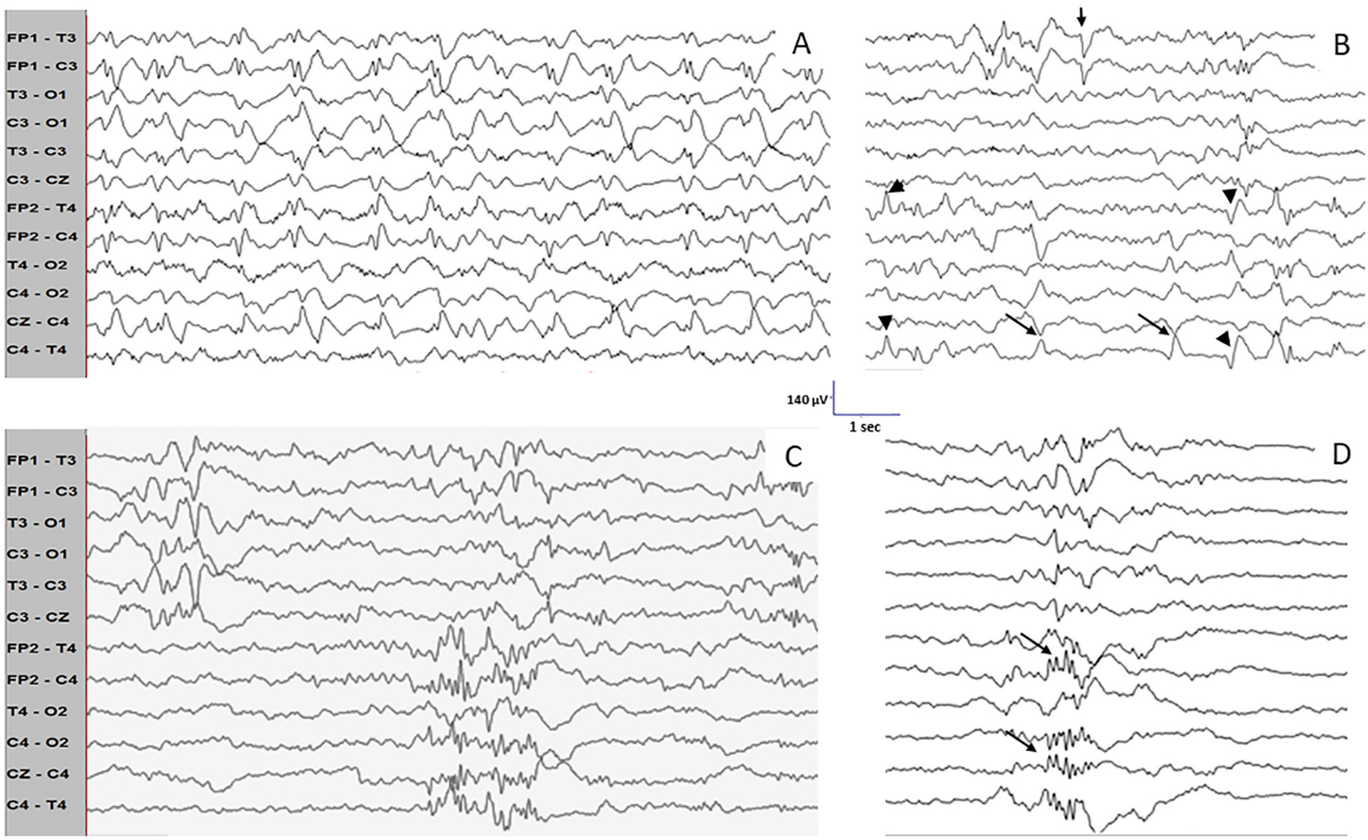

Fig. 1. Samples of EEG tracings in neonate number 4, with ischemic stroke in the left temporal parietal cerebral area. A) Ictal: bilateral discharge of rhythmic sharp waves (1 Hz). Postictal epoch: B) Rolandic (inclined arrows), temporal (head arrow), and frontal (vertical arrow) transient sharp waves; C) interhemispheric asynchrony; and D) discontinuous pattern and interhemispheric asymmetry with rapid activity only in right hemisphere (arrows).

background EEG and increase the severity of neurodevelopmental sequelae. The purpose of the present study is to analyze: 1) the background EEG activity of conventional EEG by visual and quantitative analysis through the time-course of acute electrical seizures secondary to ischemic perinatal stroke, and 2) the effectiveness of early and intensive seizure treatment monitored by video-EEG to amend and/or reverse the background EEG abnormalities.

2. Methods

2.1. Patients

From January 2008 to December 2014, 11 neonates with the diagnosis of ischemic stroke (confirmed by MRI) were recruited; 8 with focal unilateral stroke, 2 with multistroke, and 1 with hemorrhagic frontal infarct and intraventricular hemorrhage.

Standard protocol approvals, registrations, and patient consent. The study was approved by the Research Ethics Committee of our hospital. Written informed parental consent was obtained.

2.2. Procedure

All infants underwent video-EEG monitoring from the time of clinical suspicion until 24–48 h after full control of seizures was achieved. Only when the EEG seizures were confirmed, we started treatment with midazolam and lidocaine following the protocol established in our neonatal intensive care unit (Supplemental file). The same continuous infusion dose of midazolam and/or midazolam plus lidocaine to control EEG seizures was maintained for an additional 36–48 h. Subsequently, the infusion rates (first lidocaine and then midazolam) were reduced until its total withdrawal 3–4 days later.

We used a portable digital video-EEG (XLTEK 2568 by Bristol Circle), incorporating XLDB Software Version 6.0.0 Build 632 for video-EEG recording. Cerebral electrodes were placed according to the modified international 10/20 system adapted for neonates. Various montages were used with bipolar recording channels covering 9 cerebral anatomic regions: left and right frontopolar (Fp1, Fp2), temporal (T3, T4), central (C3, C4), and occipital (O1, O2), as well as central midline (Cz) electrodes. The recording also included 2 polygraph channels: 1 for chest movements and 1 for the electrocardiogram. The methodology and technical adjustments of EEG recording complied with previous recommendations [11].

2.3. Parameters

2.3.1. Clinical seizure

After observing video-EEG monitoring, the clinical seizures were classified as subtle, clonic, tonic or myoclonic following the classification of Volpe [12].

2.3.2. EEG visual analysis

2.3.2.1. EEG seizure. Sudden abnormal EEG activity in repetitive stereotyped waveform (mono, bi or polyphasic) with clearly distinguishable onset and end, with a minimum 2 µV amplitude lasting for > 10 s in at least one EEG channel (Fig. 1A). We considered a Status Epilepticus to be present when the accumulated duration of seizures comprises ≥ 50% of an arbitrarily defined 1-hour epoch [13]. Seizures were classified either as exclusively EEGs (without clinical manifestations) or electroclinical (correlated in neonatal behavior). We measured: 1) Seizure burden (total duration of EEG seizures in minutes); and 2) Time elapsed from onset to seizure control in hours and/or minutes. We identified the brain area where the