Clinical Neurophysiology 119 (2008) 985–992

www.elsevier.com/locate/clinph

NREM sleep instability in children with sleep terrors: The role of slow wave activity interruptions

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Accepted 12 January 2008
Available online 29 February 2008

Abstract

Objective: To evaluate NREM sleep instability, as measured by the cyclic alternating pattern (CAP), in children with sleep terrors (ST) vs. normal controls.

Methods: Ten boys (mean age: 8.5 years, range 5–13) meeting the following inclusion criteria: (a) complaint of ST several times a month, (b) a history of ST confirmed by a third person, and (c) a diagnosis of ST according to the ICSD-2 criteria. Eleven age-matched control children with parental report of at least 8.5 h of nightly sleep, absence of known daytime consequences of sleep disorders were recruited by advertisement from the community. Sleep was visually scored for sleep macrostructure and CAP using standard criteria.

Results: Sleep macrostructure showed only a significantly increased number of awakenings per hour and reduced sleep efficiency in ST subjects. CAP parameters analysis revealed several significant differences in ST vs. controls: an increase of total CAP rate in SWS, of A1 index in SWS and of the mean duration of A phases while B phases had a decreased duration, exclusively in SWS. The normalized CAP interval-distribution graphs showed significant differences in SWS with interval classes $10 \leqslant i < 35$ s higher in children with ST and intervals classes above 50 s higher in normal controls.

Conclusions: Children with ST showed faster alternations of the amplitude of slow EEG bursts during SWS. This abnormally fast alternation of the EEG amplitude in SWS is linked to the frequent intrusion of CAP B phases interrupting the continuity of slow delta activity and could be considered as a neurophysiological marker of ST.

Significance: This abnormal alternation of the EEG amplitude in SWS is associated with the occurrence of parasomnias and might be considered as a neurophysiological marker of disorders of arousal.

Keywords: Sleep terrors; Parasomnias; Cyclic alternating pattern; NREM sleep instability

1. Introduction

The International Classification of Sleep Disorders (ICSD-2) defines parasomnias as "undesirable physical events or experiences that occur during entry into, within, or during arousals from sleep" (AASM, 2005). The disorders of arousal (DOA) are a subset of parasomnias and include confusional arousals (CA), sleepwalking (SW), and sleep terrors (ST). These disturbances occur most often during slow-wave sleep (SWS) but can also occur during sleep stage 2 or late in the night (Broughton, 2000; Kavey et al., 1990; Mason and Pack, 2007). In particular, DOA

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1388-2457/$34.00
doi:10.1016/j.clinph.2008.01.015

tend to occur in the first third of the night, when SWS is most prominent, and are characterized by an incomplete transition from slow-wave sleep, automatic behavior, altered perception of the environment, and a varying amount of amnesia (Mason and Pack, 2007).

Although the sleep architecture in DOA does not show significant differences from controls (Espa et al., 2000; Pressman, 2004; Zucconi et al., 1995), several studies have shown subtle alterations of NREM sleep in adults, represented mostly by a high degree of arousal from SWS and by a peculiar EEG pattern defined as hypersynchronous delta activity (HSD) (Espa et al., 2000; Gadreau et al., 2000; Guilleminault et al., 2005a; Pilon et al., 2006; Pressman, 2004; Zucconi et al., 1995), described as continuous high-voltage (>150 μV) delta waves occurring during SWS or immediately prior to an episode (Pilon et al., 2006).

This activity was first noted to precede sleepwalking events by Jacobson et al. (1965) although subsequent studies have yielded unclear results, with sleepwalking or sleep terror episodes being occasionally (Espa et al., 2000; Guilleminault et al., 2005b), often (Guilleminault et al., 1998), or always (Espa et al., 2000; Guilleminault et al., 2001) associated with HSD. A more recent investigation found that the frequency of HSD in the EEG of adult sleepwalkers was dependent on the EEG derivation used (presence of a frontocentral gradient) (Pilon et al., 2003). Pilon et al. (2006) also confirmed this frontocentral gradient of HSD and showed that this phenomenon is more evident following sleep deprivation.

HSD and arousals from SWS may be present in patients without clinical history of sleepwalking or other parasomnias and, on the contrary, patients with a clear history of violent parasomnias may not have HSD or arousals from SWS. Because of these discrepancies, HSD and arousals from SWS are thought to have a low specificity and sensitivity for the diagnosis of NREM parasomnias (Pilon et al., 2006) and their eventual usefulness as diagnostic markers for DOA remains to be determined (Pressman, 2007).

It is important to take into account that HSD has been defined as high-voltage (>150 μV) delta waves occurring during SWS or immediately prior to a parasomnia episode, solely in adults (Jacobson et al., 1965; Guilleminault et al., 1998, 2001; Espa et al., 2000; Schenck et al., 1998; Pilon et al., 2006). On the contrary, SWA recorded from C3–A2 or C4–A1 in an infant or child is often 100–400 μV (Grigg-Damberger et al., 2007). Thus, the current definition of HSD applied to a pediatric group of subjects would indicate that even normal controls have, almost all, this EEG pattern. For this reason, HSD does not seem to be appropriate for the description of children's SWA with or without parasomnia.

Since high-amplitude waves are also part of the cyclic alternating pattern (CAP), and hypersynchronous slow delta is part of the phase A1 and possibly A2 of the CAP (Guilleminault et al., 2006), other studies have tried to evaluate CAP in SW and ST subjects, with conflicting results. Zucconi et al. (1995) found an increase of A1% and of CAP rate, and a decrease in phase B duration. Guilleminault et al. (2005a, 2006), also found an increase in CAP rate but also in A2 and A3 index, while A1 index was decreased. For these reasons the aim of our study was to accurately evaluate sleep architecture, CAP, and the time structure of EEG slow oscillations in subjects with DOA: sleep terror (ST).

2. Methods

2.1. Subjects

Ten boys (mean age: 8.5 years, range 5–13) were included in this study because they met the following inclusion criteria:

(1) Complaint of ST several times a month.
(2) A history of ST confirmed by a third person.
(3) Diagnosis of ST according to the ICSD-2 (AASM, 2005) criteria, i.e., (A) a sudden episode of terror occurring during sleep, usually initiated by a cry or loud scream, that is accompanied by autonomic nervous system and behavioral manifestations of intense fear; (B) at least one of the following associated features was present: difficulty in arousing the person, mental confusion when awakened from an episode, amnesia (complete or partial) for the episode, dangerous or potentially dangerous behaviors; (C) the disturbance was not better explained by another sleep disorder, medical or neurological disorder, mental disorder, medication use or substance use disorder.

Eleven age-matched children with parental report of at least 8.5 h of nightly sleep, absence of known daytime consequences of sleep disorders (e.g., daytime sleepiness, cataplexy, hyperactivity, morning headache, mouth breathing), and normal health were recruited by advertisement from the community, to serve as control subjects. These children also had complete charts and underwent similar 8.5-h polysomnographic recordings.

Exclusion criteria for all participants consisted of the following: (1) the presence of a major psychiatric disorder; (2) the use of drugs that could influence the sleep EEG; (3) the presence or history of a neurologic disorder including epilepsy. In particular, there were no anamnestic information or electroencephalographic signs of an underlying epileptic disorder and all patients included showed, after the participation to this study, a prompt and excellent response to the administration of L-5-hydroxytryptophan, a drug which we have already shown to be effective in this disorder and represent the first choice treatment for ST in our lab (Bruni et al., 2004).

All parents were asked to sign a consent form approved by the institution in which sleep recordings were carried out.