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# Paroxysmal nonepileptic events in children with epilepsy

Yuji Ito[a,b], Hiroyuki Kidokoro[a,b], Tamiko Negoro[a], Masaharu Tanaka[a], Yu Okai[a], Yoko Sakaguchi[a], Chikako Ogawa[a], Tomoya Takeuchi[a], Atsuko Ohno[a], Hiroyuki Yamamoto[a], Tomohiko Nakata[a], Satoshi Maesawa[b], Kazuyoshi Watanabe[a], Yoshiyuki Takahashi[a], Jun Natsume[a,b,*]

[a] Department of Pediatrics, Nagoya University Graduate School of Medicine, Aichi, Japan
[b] Brain & Mind Research Center, Nagoya University, Aichi, Japan

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ABSTRACT

*Objective:* The aim of this study was to clarify the characteristics of paroxysmal nonepileptic events (PNEs) suspected as being epileptic seizures by families of children with epilepsy.
*Methods:* The video-EEG (vEEG) recordings of habitual paroxysmal events in children with epilepsy at Nagoya University Hospital between October 2006 and January 2016 were reviewed. Based on the doctor's suspicion before the vEEG, the PNEs were divided into two groups that included PNEs suspected as epileptic seizures and PNEs suspected as PNEs. PNEs in the former group were classified based on the suspected seizure type.
*Results:* Of 886 habitual paroxysmal events, vEEG confirmed that 83 events (68 children) were PNEs. The median age of the 68 children was 3.2 years. Concurrent epilepsies included focal epilepsies (n = 33), infantile spasms (n = 16), and other types (n = 19). The most common types of PNEs were sleep myoclonus (n = 11), followed by stereotypies (n = 9), awake myoclonus (n = 8), paroxysmal ocular deviations (PODs, n = 8), and tonic posturing (n = 8). Even after direct observation or video viewing, the doctors suspected epileptic seizures in all three of the PODs and two of the tonic posturing children. Before the vEEG, however, the accurate visual information led to the speculation that the four psychogenic and two sleep myoclonus events were all PNEs. Myoclonus, stereotypies, and head drops were often misdiagnosed as epileptic spasms, while PODs and tonic posturing were often misdiagnosed as focal seizures with motor components. Additionally, staring and motion arrest during a drowsy state were often misdiagnosed as focal dyscognitive seizures. Seven of eight patients with PODs had epileptic spasms that were concurrent with epileptic seizures. A diffuse cerebral lesion or reduced visual acuity was seen in seven patients with PODs.
*Conclusion:* We re-emphasize that vEEG is essential for accurate diagnosis and provides evidence for listing POD in the differential diagnosis of oculomotor paroxysmal events.


## 1. Introduction

Despite prolonged hospitalization and high costs, video electroencephalography (vEEG) monitoring is the gold standard for making an accurate diagnosis of epilepsy (Asano et al., 2005; Watemberg et al., 2005). In addition, in some cases, home-video recording and video-ambulatory EEG recording have also proven to be valuable tools (Lawley et al., 2016; Manfredonia et al., 2016). Accurate diagnosis can prevent unnecessary medication, redundant restrictions of daily routines, and excessive anxiety in the patients and their family. Nevertheless, epilepsy treatments are often based on the history of seizure manifestations and the interictal EEG findings. Thus, this could be a potential risk, since it could lead to the misdiagnosis of paroxysmal nonepileptic events (PNEs) as epileptic seizures (Syed et al., 2011).

PNEs are episodes of paroxysmal changes involving movement, sensation, or consciousness that resemble epileptic seizures without any accompanying electroencephalography (EEG) changes (Kotagal et al., 2002; Metrick et al., 1991). In epilepsy patients of all ages, PNEs are not considered rare, with about 10–20% of the patients being treated for seizures at epilepsy centers diagnosed as having them (Lesser, 1996; Meierkord et al., 1991). Although

* Corresponding author at: Department of Pediatrics, Nagoya University Graduate School of Medicine, 65 Tsurumai-cho, Showa-ku, Nagoya, Aichi 466-8550, Japan.
*E-mail address:* junnatsu@med.nagoya-u.ac.jp (J. Natsume).

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psychogenic events account for the majority of the PNEs observed in adults, there are a wide variety of PNEs seen in children, including cases due to physiologic causes and organic disorders (Canavese et al., 2012; Patel et al., 2007; Uldall et al., 2006). Two previous studies reported finding similar features for the PNEs between children with and without epilepsy (Kim et al., 2012; Montenegro et al., 2008). However, since our experience suggests that the PNEs seen in children with epilepsy have different characteristics, this makes an accurate diagnosis more challenging due to the concomitant developmental or intellectual disability and cerebral palsy. Furthermore, at the present time, there are only limited detailed data available for children with epilepsy.

The aim of this study was to determine the clinical characteristics of the PNEs that are observed in children with epilepsy in order to create a more accurate clinical diagnosis and prevent unnecessary tests and medications. This study also attempted to determine the kinds of PNE manifestations that can be easily misdiagnosed as true epileptic seizures.

## 2. Material and methods

The vEEG recordings of habitual paroxysmal events in children with epilepsy aged from 1 month to 18 years at Nagoya University Hospital between October 2006 and January 2016 were retrospectively reviewed. Among these events, PNEs were included in this study. PNEs were defined as paroxysmal changes in movement, sensation, or consciousness that were not associated with the seizure patterns of the scalp EEG recordings. When differences in the types of events were observed during the vEEG, the repeated vEEG data for the same patient were included in the study analysis.

Scalp EEG electrodes were placed in accordance with the international 10–20 system. Surface electromyographic and electrooculographic activities were simultaneously recorded with vEEG. The electromyographic electrodes were placed on the right deltoid, the left deltoid, or the neck. The monitoring was performed for a maximum of eight hours. Recorded vEEGs were reviewed by four child neurologists (Y.I., H.K., T.N., and J.N.). Agreement of all four child neurologists was required to confirm the diagnosis of PNEs.

PNEs were classified as either non-psychogenic or psychogenic events. Non-psychogenic events were further classified as 1) awake myoclonus, 2) stereotypies, 3) paroxysmal ocular deviations (PODs), 4) tonic posturing, 5) head drops, 6) staring, 7) motion arrest during a drowsy state, 8) body movements in sleep, 9) sleep myoclonus, 10) parasomnias except sleep myoclonus, and 11) other. The features of POD have been previously described as follows: 1) it can be detected both at rest and during active viewing; 2) the direction of the eye deviation is mainly horizontal or upward; and 3) their duration is several seconds (Salati et al., 2002). Staring is defined as a daze during wakefulness and is considered to be physiologic or organic in origin. Body movements observed in sleep are defined as all movements that occur during sleep other than the parasomnias, such as sleep myoclonus, night terrors or sleep starts.

Psychogenic events were classified based on a previous report, as follows (Seneviratne et al., 2010). Rhythmic motor events were characterized by rhythmic movements involving the extremities and trunk. Complex motor events were characterized by complex and multifocal movements of the extremities. Dialeptic events were characterized by a coma-like state with no movements. Nonepileptic auras were characterized by various subjective sensations without any external manifestations. Mixed events were the combination of any of the preceding types.

Medical charts were reviewed to investigate the clinical data, MRI, and interictal EEG findings. The types of concurrent epilepsies, neurological disorders except epilepsy, the frequency of PNEs at vEEG, and the changes made in the treatment after the vEEG were examined. Whether child neurologists diagnosed the PNEs by direct observation or home video before the vEEG was also clarified. To analyze the difficulty in differentiation between PNEs and true epileptic seizures without vEEG, the PNEs were divided into two groups based on the clinical suspicions of the child neurologists before the vEEG. The children were placed into either the PNEs suspected as epileptic seizures group or the PNEs suspected as PNEs group. The suspected epileptic seizure type was also investigated in the former group.

This study was approved by the Research Ethics Committee of the Nagoya University Graduate School of Medicine.

**Table 1**
Clinical characteristics of patients and paroxysmal nonepileptic events.

| Patients characteristics | Number of patients (n = 68) |
|---|---|
| Male sex | 39 (57%) |
| Developmental delay | 56 (82%) |
| Abnormal brain MRI findings | 43 (63%) |
| Concurrent epilepsy | |
| Focal epilepsy | 33 (49%) |
| structural/metabolic | 27 |
| unknown | 6 |
| Infantile spasms | 16 (24%) |
| structural/metabolic | 13 |
| unknown | 3 |
| Other[a] | 19 (28%) |
| **Event characteristics** | **Number of events (n = 83)** |
| Age at onset of PNEs (years), range (median) | 0–17(3.0) |
| < 1 year | 15 |
| 1–3 years | 25 |
| 3–6 years | 17 |
| 6–12 years | 19 |
| 12–18 years | 7 |
| Age at vEEG (years), range (median) | 0–17(3.2) |
| Frequency of PNEs at vEEG | |
| Daily | 82 |
| Weekly | 1 |
| Number of drugs at vEEG, range (median) | 1–4(2.1) |
| Interictal epileptiform discharges at vEEG | 79 (95%) |

MRI, magnetic resonance imaging; PNEs, paroxysmal nonepileptic events; vEEG, video-electroencephalography.

[a] Other characteristics include Lennox-Gastaut syndrome (n = 2), Dravet syndrome (n = 1), progressive myoclonic epilepsy (n = 1), juvenile myoclonic epilepsy (n = 1), Rasmussen syndrome (n = 1) and unclassified epilepsy (n = 13).

## 3. Results

### 3.1. Diagnosis of PNEs

Of 886 habitual paroxysmal events in children with epilepsy, vEEG diagnosed 83 (9.4%) paroxysmal events of 68 children as PNEs. Table 1 lists the clinical characteristics of epilepsy patients and PNEs. Nine patients had two types of PNEs, and three patients had three types of PNEs. The duration of vEEG ranged from one to eight hours (median, two hours). Fig. 1 shows the frequency of PNEs in all of the age groups. The most common PNEs included sleep myoclonus (n = 11), followed by stereotypies (n = 9), awake myoclonus (n = 8), PODs (n = 8), and tonic posturing (n = 8). Of the seven observed psychogenic events, three were classified as nonepileptic auras, two as rhythmic motor events, one as a complex motor event, and one as a dialeptic event. PODs and tonic posturing were more commonly found in children younger than three years old (75%). Psychogenic events were more commonly found in children older than six years (86%). Regarding neurological disorders other than epilepsy, it is notable that seven of eight patients with tonic posturing had cerebral palsy.