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Original article

Paroxysmal EEG abnormalities and epilepsy in pervasive developmental disorders: Follow-up study until adolescence and beyond

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Abstract

This study examined paroxysmal abnormalities and epilepsy in EEG for individuals with pervasive developmental disorders (PDD) in two parts: first with a large number of subjects ($n = 1624$); and second with extracted subjects followed from $\leqslant 5$ years into adolescence and beyond ($n = 92$). Many paroxysms in PDD patients in their childhood tended to appear at various sites and the same held for paroxysms at the time of epilepsy onset. However, in adolescence and beyond, paroxysms in the frontal region prevailed as those appearing at sites other than the frontal region tended to disappear. The same held for paroxysms at the time of epilepsy onset. These paroxysms in the frontal area characteristic of PDD were named "Paroxysms at F." It was suggested that functional abnormality in the frontal region exists in PDD through paroxysmal EEG abnormalities and epilepsy.

Keywords: Pervasive developmental disorders; Paroxysmal abnormalities; Paroxysm at F; Epilepsy

1. Introduction

Various studies have already shown that patients with pervasive developmental disorders (PDD) are prone to develop epilepsy, which occurs most commonly in adolescence [1–5]. Our study in 1997 on autism and epilepsy reported the following characteristics of paroxysmal abnormalities of Electroencephalography (EEG) for individuals with autism: (1) paroxysms appeared more often in the frontal area as subjects grew into adolescence; (2) these paroxysms in the frontal area were behind the prevalence of epilepsy in individuals with autism; and (3) since paroxysms in cases without epilepsy also appeared in the frontal area, paroxysms in the frontal area represent a common pathophysiology unique to autism. We named these paroxysms in the frontal area among autistic subjects "Paroxysms at F" [3]. About a decade has passed since our last study and the diagnosis of PPD now includes not only autism, but also cases such as atypical autism and Asperger syndrome. Patients without *mental* retardation are also on the rise. During this period, various reports have been made regarding the distribution of paroxysmal EEG abnormalities in PDD [6–11].

We once again conducted a follow-up study on paroxysmal EEG abnormalities in PDD with a large number of cases including adequate number of those without mental retardation, regarding the changes in paroxysmal abnormalities according to age and the distributions of paroxysmal abnormalities at the time of epilepsy onset. This study comprised two parts. Part I accumulated data for a large group of 1624 cases. Part II investigated

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detailed data for 92 extracted cases with sufficient follow-up.

2. Part I: Findings in a large group

2.1. Subjects

Subjects comprised 1624 PPD cases (1319 males, 305 females) with a mean age of 12 years and 2 months (range, 3–41 years). Diagnoses were determined according to the ICD-10, [12] falling under the category of autism, atypical autism, Asperger syndrome and other PDDs.

As for intellectual levels evaluated by Binet Intelligence Scale , Wechsler Intelligence Scale for Children or Wechsler Intelligence Scale for Adults, 740 cases were not retarded (mean age, 13 years; range, 3–38 years), 313 cases were mildly retarded (mean age, 14 years 6 months; range, 3–37 years), 227 cases were moderately retarded (mean age, 14 years 2 months; range, 3–36 years) and 344 cases were severely retarded (mean age, 17 years, 4 months; range, 3–41 years). Analysis of variance was used to investigate age factors but showed significant difference ($P < 0.001$; $F(3,1620) = 142.51$) so we applied the Bonferroni correction to address the problem of multiple comparisons. The result indicated that age became significantly older as intellectual level became more retarded.

Of the 1624 cases, 169 cases (10.4%; 130 males, 39 females) had developed epilepsy.

2.2. Methods

A total of 3872 EEG records were available for analysis among the 1624 cases after excluding EEGs without sleep records. The distribution of paroxysms appearing in all records and records broken down by age groups were reviewed. Findings at the time of epilepsy onset in this study mean records taken within 1 year before or after onset and the distribution of paroxysms here was reviewed. In cases where abnormalities appeared at multiple foci in one record, all foci were counted. Conversely, in cases where paroxysms appeared at the same focus more than once, these were counted as one focus. The records excluded 6-Hz phantom, 6- and 14-Hz positive spikes and slow-wave bursts without spikes (sharp) from paroxysmal abnormalities. Foci of paroxysms were divided into 8 groups. First, according to electrode positions in the 10–20 system, those appearing at Fp1/2, F3/4, F7/8 and Fz were classified as Group F; C3/4 and Cz as Group C; P3/4 and Pz as Group P; T3/4 and T5/6 as Group T; and O1/2 as Group O. In addition, those appearing extensively in the centrotemporoparietal regions were classified as Group CTP, those appearing diffusely were classified as Group D, and the few appearing simultaneously at Fp and O were classified as the FpO group.

The number of EEG records available for each age group is shown in Fig. 1.

2.3. Results

Of the 1624 subjects, 619 (38.1%) showed paroxysmal abnormalities in EEG at least once during follow-up. With respect to intellectual levels, 206 subjects (27.8%) were not retarded, 119 (38.0%) were mildly retarded, 98 (43.2%) were moderately retarded and 196 (57.0%) were severely retarded, resulting in higher ratio of paroxysm incidence with greater retardation ($p < 0.0001$; $\chi^2 = 87.482$; $df = 3$).

Of the 3872 EEG records, 1395 showed paroxysms (Fig. 1).

Paroxysms gradually increased in early childhood and when the subjects reached 7 years old and thereafter, the ratio of paroxysm occurrence was quite high at around 40%.

The distribution of paroxysms among the 1395 records was analyzed. The number of paroxysms totaled 1563, with more than one appearing in a record in some cases. The breakdown was as follows: 744 in Group F (106 at Fp1/2; 623 at F3/4 and Fz; 15 at F7/8), 38 in Group FpO, 131 in Group C, 132 in Group CTP, 167 in Group P, 82 in Group T (56 at T3/4; 26 at T5/6), 137 in Group O and 132 in Group D.

Looking at data with respect to each age group, in Groups F, FpO, C, CTP, P, T, O and D (Fig. 2), paroxysmal abnormalities appeared in various site groups at $\leqslant$10 years old, but those appearing in the F group started to gradually increase and came to make the majority of abnormalities at $\geqslant$11 years old.

Of the 169 cases with epilepsy, 6 cases developed epilepsy at 0 years old, 2 cases at 1 years old, 2 cases at 2 years old, 8 cases at 3 years old, 4 cases at 4 years old, 9 cases at 5 years old, 7 cases at 6 years old, 15 cases at 7 years old, 4 cases at 8 years old, 7 cases at 9 years old, 7 cases at 10 years old, 7 cases at 11 years old, 12 cases at 12 years old, 11 cases at 13 years old, 13 cases at 14 years old, 11 cases at 15 years old, 11 cases at 16 years old, 9 cases at 17 years old, 6 cases at 18 years old, 5 cases at 19 years old, 4 cases at 20 years old, 1 case at 21 years old, 2 cases at 22 years old, 2 cases at 24 years old, 1 case at 25 years old, 1 case at 26 years old, 1 case at 28 years old and 1 case at 31 years old (Fig. 3). EEG records at the time of epilepsy onset were not available for 46 of the 169 cases. In addition, 35 cases were seen in which paroxysmal abnormalities were not detected. Paroxysmal abnormalities were detected in the remaining 88 cases.

Foci are shown in Fig. 4. Foci of paroxysmal abnormalities in childhood were widely distributed, while abnormalities in EEGs almost always appeared in Group F for those who developed epilepsy during or after adolescence.