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State of Bioelectrical Brain Activity in Children with Cerebral Palsy

Nabiyeva Nozima Abdurahimovna
Bukhara State Medical Institute named after Abu Ali ibn Sina

Abstract
Cerebral palsy describes the most common physical disability of childhood and occurs in 1 in 500 live births. Historically, diagnosis was made between 12 and 24 months of age, but can now be made before 6 months of corrected age. We have summarized the best available evidence for a systematic review of the best available evidence for early and accurate diagnosis of cerebral palsy and for early intervention specific to cerebral palsy after early diagnosis to optimize neuroplasticity and function.

Keywords: epilepsy, cerebral palsy, EEG video monitoring, hyperkinesis, neurophysiological markers.

Relevance of the problem. The World Health Organization (WHO) has recognized cerebral palsy (CP) as the most common cause of childhood disability in most countries, with a global prevalence exceeding the threshold of 17 million people [1,9]. Symptomatic epilepsy (SE) is an important complication that worsens the clinical course of the disease in cerebral palsy, with an incidence of 15 to 94% of children and adults [2,6].

Today, EEG plays the greatest role in identifying epileptic activity of the brain in cerebral palsy, indicating the focus of its location [3,4]. EEG with provoking tests, computer analysis of EEG with spatial localization of the focus of pathological activity and EEG video monitoring are the most widely used non-invasive research methods. EEG is the visualized result of the functional bioelectrical activity of the brain, and has some difficulties in children. But there are no contraindications to its implementation [7,10,12].

Bioelectrical activity of the brain allows us to determine the type of epileptic seizures in cerebral palsy. In addition, it is possible to differentiate them from hysteria, hyperkinesis, tics and fainting in children of different etiologies [5,11].

The purpose of the study is to establish neurophysiological markers of epilepsy and predict SE in patients with cerebral palsy.

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Materials and methods of research. We examined 255 children aged 3 to 14 years with a diagnosis of cerebral palsy, who were hospitalized in the Republican children's psychoneurological hospital in the period 2020-2022. Patients were divided into 3 groups: 1st main group - 102 patients with cerebral palsy complicated with SE, 2nd comparison group - 153 patients with cerebral palsy without paroxysmal seizures, 3rd control group - 50 healthy children of similar age.

At baseline, all children underwent routine EEG. In our studies, we used the standard system for describing EEG patterns and groups according to E.A. Zhirmunskaya (1991) and is the basis for neuroimaging, to give a separate assessment of the EEG for the appropriate age of the child.

We recorded the EEG of patients with cerebral palsy in a state of passive wakefulness, with their eyes closed. To assess verbal changes in computer EEG, the following criteria were included:

1. background recording data;
2. the presence of changes during rhythmic photostimulation with an increasing frequency from 6 to 17 Hz;
3. The appearance of shifts during 3 minutes of hyperventilation.

Research results and discussion. We divided all routine EEGs into 5 types according to the classification of E.A. Zhirmunskaya:

Type I – organized (normal EEG),

Type II – hypersynchronous (monorhythmic),

Type III – desynchronous (normal variant),

Type IV – disorganized (with a predominance of α-activity),

Type V – disorganized (with a predominance of θ- and δ-activity).

Organized type I - the main component on the EEG was the α-rhythm, taking into account the age characteristics of the child. Normally, the α rhythm has the highest amplitude (50-70 μV) in the occipital leads. Slow waves are expressed according to the development of the child. Type I refers to the normal type of EEG. Among healthy children in the control group, 31 (62.0%) had a normal EEG with high confidence (R). 4 (2.6%) children in the comparison group also had cerebral palsy without SE.

A normal EEG was recorded. Despite the presence of epileptic paroxysms outside the attack, an organized type of EEG was recorded in 2 (1.9%) patients of the main group of cerebral palsy with SE in the interictal period against the background of AED.

Comparative analysis of EEG routine characteristics of patients with cerebral palsy, n (%)

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Table 1.

Types of EEG	Cerebral palsy without SE n=153, (%)	Cerebral palsy with SE n=102 (%)	Healthy children n=50, (%)
I.O organized	4 (2 , 6)	2 (1.9)	31 (62.0)
II. Hypersynchronous	11 (7.2)	3 (2.9)	13 (26.0)
III. Desynchronous	14 (9.2)	5 (4.9)	6 (12.0)
IV . Disorganized with predominance of α-activity	58 (37.9)	32 (31.4)	-
V. Disorganized with predominance of θ- and δ-activity	66 (43.1)	60 (58.9)	-

Slow waves are expressed according to the development of the child. Type I refers to the normal type of EEG. Among healthy children in the control group, 31 (62.0%) had a normal EEG with certainty ($P<0.05$). In 4 (2.6%) children in the comparison group with cerebral palsy without SE, a normal EEG was also recorded. Despite the presence of epileptic paroxysms outside the attack, an organized type of EEG was recorded in 2 (1.9%) patients of the main group of cerebral palsy with SE in the interictal period against the background of AED.

The hypersynchronous (monorhythmic) type is characterized by registration throughout the entire zone of the α-rhythm, low-frequency ß-activity, or the rhythmic appearance of θ-activity. With this type of oscillations, their zonal differences are lost. When the α-rhythm dominates, it is considered moderately disturbed; in the presence of high ß-activity, it is characterized as significantly impaired EEG. Type II EEG was recorded in 13 (26.0%) healthy children in the control group. In the comparison group, a monorhythmic EEG type was established in 11 (7.2%) patients with cerebral palsy without SE and among children in the main group in 3 (2.9%) patients with cerebral palsy with SE.

Desynchronous type III, essentially also refers to a variant of the norm, where low-amplitude waves are recorded on the EEG, α-waves are decreased, sometimes completely absent, and ß-activity is somewhat less pronounced. Slow θ- and δ-waves characteristic of this type are recorded, but of small amplitude. In the group of healthy children, in 6 (12.0%) cases, a desynchronous type of EEG was established with high confidence ($P<0.01$). In the comparison group, 14 (9.2%) and the main group 5 (4.9%) had a borderline-normal EEG variant.

IV disorganized type with a predominance of α-activity is characterized by the appearance of predominantly disorganized α-activity. ß-activity is also often enhanced, an increase in the index of

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θ- and δ-waves was noted, and peak waves appear. In our studies, type IV was not recorded among healthy children. With great confidence, in the comparison group in 58 (37.9%) and the main group in 32 (31.4%) patients, a disorganized type with a predominance of α-activity was established.

Disorganized with a predominance of θ- and δ-activity, characterized by where δ-activity was poorly expressed and single α-waves. With this type, the entire sequence of biopotentials α-, ß-, θ- and δ-oscillations is disrupted. Type V made up the largest part of the main group - 60 (58.9%) cases and the comparison group - 66 (43.1%) cases. Among the children of the healthy group, not a single case of type V was identified. The presence of this type of EEG indicates destructive organic lesions of the brain.

Establishing the type of epileptiform EEG activity in our studies was of great value, especially during the patient's seizures. In the period between attacks, the diagnostic value decreases slightly.

We were not always able to record epileptic activity in a standard EEG study. Epileptic activity on the EEG often does not appear during the day when the child is awake. For To detect epileptiform activity, we did video EEG monitoring. Brain biopotentials were recorded for several hours. The research results were processed by a computer program.

EEG pathological and “conditionally pathological” epileptiform activity was recorded more in children with a hereditary history of epilepsy in both groups. In patients in the comparison group, cerebral palsy phenotypically without SE was identified in 38.5% of cases as “conditional epileptic activity.”

Thus, for diagnosing epilepsy, the conditional form of wave activity is not always an absolute basis. In such cases, we did not make a diagnosis of “symptomatic epilepsy.”

Conclusion. According to the results of our observations, conditionally epileptic activity can most likely transform into epilepsy, since such children have a hereditary predisposition to epilepsy. These patients should be under the supervision of a neurologist, epileptologist and periodically, every 3 months, should undergo a special examination. For patients with “conditionally epileptic activity” we have developed a special rehabilitation algorithm.

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