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Electroencephalography in Infant Mental Health Disorders: Medical Education

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Abstract: Modern electroencephalography is largely mathematical method. According to many researchers, "basic" mathematical method is a method of EEG spectral analysis. We also used a coherent analysis of the EEG. Several authors recommend routine electroencephalography, EEG monitoring: with perinatal asphyxia, with seizures, tremor, infants with mechanical ventilation, in children with meningitis and malformations, in babies with heart defects or congenital diaphragmatic hernia, in children with severe hypoglycemia or metabolic diseases (Hellstom-Westas L. et al., 2008).

The mathematical EEG in neuropsychiatric disorders early age (Perinatal encephalopathy (HIE), febrile seizures, affective-respiratory paroxysms) confirms the clinical, morphological and neuroimaging data on cortical lesions in the areas of regional cortical blood flow between the anterior, middle and posterior cerebral arteries. The results show a delay electrogenesis EEG during wakefulness and sleep pattern maturation that are associated with neuronal loss. In addition, the visual and mathematical analysis of EEG builds neuro-psychiatric disorders early age, as if in a hierarchy. When HIE changes are expressed minimally (22%), with the affective-respiratory paroxysms EEG changes are expressed in moderate (one-third of the cases), with febrile seizures (more than half the time) are expressed to the maximum.

Key words: mathematical EEG, spectral analysis EEG, coherent analysis EEG, Perinatal encephalopathy (HIE), febrile seizures, affective-respiratory paroxysms

1. Introduction

Child psychiatrists, child neurologists, pediatricians have the questions to the doctor EEG (electrophysiologists). There are questions about the "convulsive", the probability of subsequent seizures. Of course, the answer to this question is important for physicians and parents of small children.

However, modern electroencephalography was largely mathematical method. EEG is experiencing a kind of "rebirth" in connection with the new features in terms of a more general view on the functional state of the brain during development. According to many researchers (Zenkov L. R., 2004; Ivanov L. B., 2000), "basic" mathematical method is a method of EEG spectral analysis. In modern devices for EEG formula applies a fast Fourier transform, which decomposes on EEG delta, theta, alpha, beta-ranges or peaks in the form of columns of

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the stored energy. The peaks of the stored energy is displayed in the graphs in different colors for better evaluation specialist. This happens instantly on all leads EEG recording. According to mathematicians, EEG can be regarded as a signal with slightly varying frequency characteristics and apply the fast Fourier transform as a variant of the trigonometric series (resembling a set of sine waves).

There are methodological limitations in the spectral analysis of the EEG. This is reflected in the programs of EEG processing unit. This is the sampling frequency (120–140 Hz), the duration of analysis periods (at least 30 sec.). The result of the spectral analysis in the form of graphs represent in terms of power fluctuations — in mkV in the "square".

Spectral analysis is applied to all bands of EEG. Spectral analysis of the alpha rhythm is particularly important for both adults and children of all ages. This activity is most common in the EEG. Alpha activity characterizes the functional state of the cerebral cortex and subcortical structures in the quiet wakefulness with eyes closed or in a darkened room. Most often there is not a single peak in the spectral analysis, and several peaks of the stored energy, which is called the multimodal alpha rhythm (Ivanov L. B., 2000). According to many researchers (Farber D., 1969; Ellingson R., 1975; Dreyfus-Brisac C., 1979, Ivanov L., 2000), it is not accidental, but due to the presence of several generators of alpha activity (cortical and depth) in the brain. Some researchers recommend allocate three ranges of alpha rhythm. Other experts, to whom we subscribe, allocate two ranges. That is, the low-frequency alpha rhythm (7.75–10 Hz, 1 alpha rhythm) and high-frequency alpha rhythm (10–13 Hz, 2 alpha rhythm).

We also used a coherent analysis of the EEG. Coherent analysis shows the relationship between the two processes and measured the correlation coefficient of 0.1 to one. If the figures correspond to the coherence of 0.1–0.3, this is evidence of a small linear relationship between the two processes. When the figures correspond to 0.7–0.9, it is indicating a high coupling of the two processes, or the fact that they originate from a single source. In assessing the functional state of the brain in health and disease coherent analysis is important for understanding the interconnections between different parts of his work in any system. It is believed that the different brain structures contribute to the formation of EEG coherence. For example, several studies have shown that the level of inter-hemispheric coherence is associated with the deep parts of the brain (the activity of stem and diencephalic structures of the brain). Levels intrahemispheric connectivity biopotentials reflect the characteristics of cortical and thalamo-cortical interactions (Boldyreva G., Sharova U., Dobronravova J., 2000; Boldyreva G., 2000). It is thought that the level of alpha-Koh is more susceptible to the effects of thalamic structures, theta Koh - hypothalamic and limbic structures, and the characteristics of delta-Koh - influences stem systems (Rusinov V. et al., 1987; Boldyreva G., Sharova U., Dobronravova J., 2000; Boldyreva G., 2000). In addition, the relationship intercentral normally characterized by high stability and low variability of the mean levels of coherence of delta and theta activity, and their decrease or increase in the EEG may be a sign of pathological changes in brain function (Grindel O., 1980; Rusinov V. et al., 1987; Boldyreva G., 2000). However, the characteristics of alpha-and beta-Koh less stable and more dependent on the characteristics of the current functional state of the brain investigated person (Rusinov V., 1987).

2. Electroencephalography in Hypoxic-Ischemic Encephalopathy: Perinatal Encephalopathy, Hypoxic-Ischemic Encephalopathy

Several authors recommend routine electroencephalography, EEG monitoring: with perinatal asphyxia, with seizures, tremor, infants with mechanical ventilation, in children with meningitis and malformations, in babies

with heart defects or congenital diaphragmatic hernia, in children with severe hypoglycemia or metabolic diseases (Hellstom-Westas L. et al., 2008). Causes of Perinatal encephalopathy are the most likely short-term suspension providing the fetus with oxygen and other nutrients (asphyxia, hypoxia) and intracranial birth trauma. According to WHO (2008), more than a million children with asphyxia have further cerebral dysfunction, developmental delay, learning difficulties at school and other problems. Cases of intracranial birth trauma are much less common and make up a fifth-tenth of all the sick infants. Clinic at Harvard University determines the frequency of hypoxia, asphyxia in newborns as 6:100 in Russia: 18-20:100 (A. S. Petruhin, 2012). The main reasons for the lack of oxygen supply of the brain are placental insufficiency, pneumonia and respiratory failure.

Cerebral blood flow is an important mechanism in the formation of Perinatal encephalopathy. Cerebral blood flow depends on blood pressure in children. By lowering the pressure, leads the centralization of the circulatory system (providing the vital organs, especially the brain). Further decrease in pressure leads to a decrease in cerebral blood flow and damage to the cells of the cerebral cortex and subcortical structures of the brain. Moreover, there is a dependency of the vascular lesion focus on gestational age. In full-term infants affected mainly the cerebral cortex, in preterm infants affected the white matter of the brain, which contains the association and pathways.

Therefore, there is often a severe Perinatal encephalopathy outcome in preterm infants. Preservation or violation of the mechanism of autoregulation of cerebral vascular flow is also important. Broadening or narrowing of the arteries of the brain occurs autonomously when the blood pressure. This allows blood brain. You can call it “self-defense” the child’s brain, which leads to the conservation of the vital structures of the brain. Medulla has a high sensitivity and a lack of oxygen reacts with increased blood flow. At the same time, the white matter of cerebral hemispheres has a low vascular sensitivity, which leads to the defeat of the brain with poor circulation. It is known that the lesion of the cerebral cortex occurs in 35–85% of infants with hypoxic-ischemic encephalopathy (HIE) (Zanelli S. et al., 2008). Hypoxia and ischemia lead to the occurrence of partial insults of the marginal vasculars of the pools of various vessels. Hypoperfusion leads to infarcts cortex. The affected regions include the area between the anterior, middle and posterior cerebral arteries, i.e., fronto-temporal region and the temporo-parietal cortex. For example, in the occipital lobe of the brain hypoxic-ischemic episode leads to neuronal loss and the appearance of spontaneous myelin fibers of the white matter. Macroscopic appearance of a lesion characterized by ridges and furrows, known as the “mushroom” gyrus (Zanelli S. et al., 2008). In the bilateral frontal lobes acute infarcts “watershed” type between the anterior and middle cerebral arteries are the result of cerebrovascular accidents in the first 24 hours of life. The result is the loss of neurons not only hypermielinisation but replacing the cerebrospinal fluid of the brain parenchyma (Fenichel G., 2005).

Cranial birth trauma — the second cause of perinatal encephalopathy. By the development of birth injury is the interaction of two factors: the mechanical damage during the passage of the birth canal and disorders of cerebral circulation. The most common birth injury occurs when an incorrect position of the fetus, in cause of rapid and prolonged birth, in violation of obstetric practices and abuse of surgical technique. As a result of birth trauma is damage and rupture of vasculars of the brain, and there are various localization hemorrhage. Thus, the lack of oxygen supply of the brain and birth trauma, neurochemical abnormalities in full-term infants lead to the death of brain substance mainly in cortical-subcortical structures. These parts of the brain are involved in the organization of higher mental functions such as attention, memory, oral and written language, fine motor skills and abilities to the bill succession.

Consequently, the lungs of brain damage leading to selective damage to the mental functions in school, and

severe violations lead to total damage, which affects the level of IQ. Mental functions listed above affect the level of IQ, and their partial loss does not lead to a substantial breach thereof, can be compensated. It is clear that generalized damage results in significant disruption resulting function. Premature babies hemorrhage observed predominantly in the subcortical structures containing pathways that connect different parts of the brain. Such localization of lesions leads to two types of violations. First, the brain is affected in general. Second, the broken column-organizing principle of anatomy and function. Marked the defeat of the ascending stem-subcortical-cortical interactions. So clear a high prevalence of severe mental and neurological disorders such as mental retardation, cerebral palsy, epilepsy in a group of premature children.

When cutaneous electroencephalography leading contribution to the change in bioelectric potentials and the resulting picture of the EEG pattern, making the neurons of layers III and V of the neocortex. It is known that the 18th week embryogenesis process ends neuronal migration from areas around the lateral ventricules. After 20 weeks of each neuron's crust is laid for him. Hypoxia/asphyxia lead to neuronal cell death in the above-vulnerable areas of the cortex, and to processes hypermyelination appearance glial scarring. Such areas on gross examination appear as white spots on the gray matter (marbling, status marmoratus). Cortical neuronal loss in the EEG newborns and infants should lead to a lack of bio-potentials, or low amplitude, which is confirmed in studies using amplitude-integrated EEGs (aEEG). This method is used in EEG monitoring devices of various functions newborn baby in intensive care. So van Rooij L. (2007), and de Vries L. (2006) indicate that the EEG after severe hypoxia can:

(1) not monitored activity of the cortex,
(2) celebrated continuously low level of background amplitude,
(3) recorded EEG monitoring gap at low amplitude biopotentials,
(4) mark the presence of high-amplitude flares.

There is a local paroxysmal activity in 24 (22%) children of the 110 children who underwent hypoxia that when waking EEG recorded at the age of 14 months, our data suggest. Paroxysmal activity (activity pointed high amplitude is not typical for the background recording) recorded in the fronto-temporal, or temporal-parietal cortex (Brodmann area 10, 21–23, 31–32, 39, 40). This corresponds to the localization of sites of hypoperfusion during hypoxic episode. These children suffered severe variant of hypoxia, with seizures, with severe neurological symptoms. Spectral analysis (children mean age, 6.64 months) showed that children with paroxysmal activity of the largest peak in the spectral power in the occipital cortex was observed in the theta range with a frequency of 1 Hz 4.85, while those without the sharp focal activity recorded with 5.86 frequency 1.6 Hz, the differences were significant ($p = 0.0046$, $p < 0.005$). This indicates a delay of the EEG pattern development as a result of cortical neuronal loss. Coherent analysis failed to have 10 children with paroxysmal activity, comparing them with 35 children from the sample without focal paroxysmal activity. Factor analysis showed different values and intrahemispheric interhemispheric coherence (a factor of 0.8–0.9) with respect to age, the severity of a neurological condition within each of the subgroups. Thus, in the subgroup with focal paroxysmal activity indicators hemispheric Koh in the anterior cortex in the theta and alpha-1 waves are associated with the child's age. This indicates a typical place of defeat during hypoxia-ischemia and reduced bonds for the first year of life (the processes of compensation for HIE). A similar relationship in the subgroup without paroxysmal activity is absent. This phenomenon corresponds to the known fact that the presence of voice disorders in pre-school age children who had hypoxia. In children without paroxysmal activity observed feedback HIE severity and frequency of the peak figure of rhythm. This indicates a delay of electrogenesis in children with cerebral hypoxia.

When the sleep EEG recorded under the age of 10 months (mean age 6.3±3.3 months), and 8 (1/2-1/3) of the 22 children, there is a similar local paroxysmal activity. As an indicator of maturity of the sleep EEG frequency appears not peak rate and the number of sleep spindles per minute (sigma rhythm) for Phase II of slow wave sleep. In our sample the frequency is lower in children with paroxysmal grafoelements (3.5±3.0) compared with the subgroup without (6.07±2.3, the differences are significant $p = 0.036$, $p < 0.05$). This indicates a delay in sleep pattern in children with paroxysmal grafoelements. Thus, EEG examination in infants with HIE confirms morphological data on cortical lesions in the areas between the anterior, middle and posterior cerebral arteries. The data indicate a delay in the wake of electrogenesis and maturation of sleep patterns that are associated with neuronal loss. Spectral and coherent analysis of EEG confirms the electroencephalographic data, said the location of hypoxic damage mainly in the anterior quadrants of the left cortex. This is also consistent with the morphological and neyroimaging data.

3. Electroencephalography in Febrile Seizures in Children

Febrile seizures occur most often in early childhood. Feature of febrile seizures is the possibility of developing epilepsy, a full recovery, the presence of neural infections. This reflects the lack of differentiation of neuropsychiatric abnormalities in children and different probabilities of their development. There is a relationship of febrile seizures in the autumn and spring, when the children are common respiratory infections. Known correlation between the time of occurrence of febrile seizures by the age of 18–24 months, since before and after this age range they are much less common (Nelson K., 1990). Now it is proved the presence of a genetic predisposition in the occurrence of febrile seizures. If febrile seizures were observed in the mother or the father, the risk of such seizures in children increased by five times, and if febrile convulsions were observed in both parents - the risk increases to 14 times (Hauser A., 1990).

Paroxysmal EEG changes recorded in 22% of cases (Sofianov N. et al., 1992) and are explained by genetic predisposition to epilepsy. According to our data, the waking EEG in children with febrile seizures recorded in age from 1 year to 3 years (average age 24±11.6 months) in 16 of 29 children, which is more than half the cases, there is a local paroxysmal activity (activity pointed high amplitude is not typical for the background recording). Pathological activity registered like either bilaterally (9 children), either in the right or left temporo-parietal cortex (7 cases, the fields Brodmann 21–22). Average peak frequency rhythm children without paroxysmal activity 8.07±0.65 Hz, which is significantly higher frequency rhythms have similar children with paroxysmal activity (6.08±1.5 Hz, $P = 0.00013$, $p < 0.005$).

There were significant differences in intrahemispheric connections in coherent analysis of the EEG in the left hemisphere of the range of the delta between the group without paroxysmal activity and the group with paroxysmal activity ($p = 0.036$, $p < 0.05$). It turned out that due to the factor of 0.8–0.9 in the factor analysis of indicators of age, severity of neurological status, the COG-cortical EEG relations within each of the subgroups intrahemispheric and interhemispheric coherence different. Thus, children without paroxysmal grafoelements in some factor groups were together performance or left or right hemisphere, in others - or indicators of front or rear quadrants of the EEG leads. In children with paroxysmal activity in factor groups not observed a similar locality, reflecting the diffuse lesions of the cortex.

Therefore, in children with febrile seizures observed correlation indicators similar to those reported with HIE. The detected changes are less pronounced, with a smaller local changes that may be indicative of the general

mechanisms of hypoxia-ischemia in a genetic predisposition to seizures. Small hypoxic episodes lead to convulsive response in a victim age for febrile seizures.

4. Electroencephalography in Affective-Respiratory Paroxysms in Children

The phenomenon of early childhood also carries a variety of likelihood and dependence on age. So a number of children is circular reaction to the situation (ignoring older desire to have this or that toy, the product from the store, etc.). For others, this symptom is a prerequisite to the formation of demonstrative personality traits. In the third — an forpost-symptom, “heat lightning” is possible in the future epilepsy. The fourth approach involves the development of attachment theory in the works of P. Crittenden (2006). From the point of view of the concept, affective-respiratory paroxysms are a manifestation of behavior “manipulate” children belonging to the category of insecure attachment (type C). They show the so-called “falsified” affect the interaction with close relatives, especially his mother. Confirmation of this view is the virtual absence of these reactions when communicating with other adults. Recall that it was due to inconsistency, unpredictability of the mother, and scenes from the separation of a plurality of trustees in age from 8 months to 1.5 years formed a dual attachment style.

Clinicians consider important factor in the presence or absence of an episode of “rolling” impairment of consciousness for the need for greater or smaller survey, the EEG recording. We believe that the EEG is indicated in all children with affective-respiratory paroxysms, independent of the severity or mildness of the attack. When waking EEG in children with affective-respiratory paroxysms (mean age 19.2±9.9 months), 6 out of 17 children, that is a third of cases, there is a local paroxysmal activity (activity pointed high amplitude is not typical for the background recording). Pathological grafoelements recorded or bilaterally (2 children), or in the temporo-parietal cortex right or left hemispheres (4 cases, the fields Brodmann 22–40). Average peak frequency rhythm children without paroxysmal activity 7.8±1.14 Hz, which is significantly higher frequency rhythms have similar children with paroxysmal activity (6.12±1.25 Hz, $p = 0.013$, $p < 0.05$).

When the factor analysis of indicators of age, severity of neurological status, the COG-cortical EEG relations within each of the subgroups found that communication (by a factor of 0.8–0.9) intrahemispheric and interhemispheric coherence differ. Thus, children without paroxysmal grafoelements in factor groups were together figures of the left or right hemisphere, the indicators front quadrants of the EEG leads. In children with paroxysmal activity in factor groups observed correlation between age and local paroxysmal manifestations, as well as the presence of pathological COH-ties right in the range of delta and alpha 1 and hemispheric relations in the front and rear quadrants of the hemispheres. Consequently, it is about hyperintegration in right hemisphere, increasing over time in children with paroxysmal activity. Severity of focal changes in this subgroup is inversely correlated with the index of the dominant frequency of rhythm, that is, the stronger the rhythm slowed down, the brighter the focal paroxysmal activity.

Consequently, when the affective-respiratory paroxysms only in children with abnormal EEG observed correlations of both at HIE. It is noted right-sided localization of changes, deterioration of EEG frequency performance with age, which may indicate, on the one hand, of the anoligic mechanisms of hypoxia-ischemia in these pathologies. On the other hand — with the age of the accumulation of pathological changes in the EEG in children initially with paroxysmal activity. Children without pathological changes in the EEG there are more in the shares of, and relationships with abnormal loading factor analysis Koh-EEG are less pronounced.

5. Conclusion

Thus, the mathematical EEG in neuropsychiatric disorders early age (HIE, febrile seizures, affective-respiratory paroxysms) confirms the clinical, morphological and neuroimaging data on cortical lesions in the areas of regional cortical blood flow between the anterior, middle and posterior cerebral arteries. The results also show a delay electrogenesis EEG during wakefulness and sleep pattern maturation that are associated with neuronal loss. In addition, the visual and mathematical analysis of EEG builds neuro-psychiatric disorders early age, as if in a hierarchy. When HIE changes are expressed minimally (22%), with the affective-respiratory paroxysms EEG changes are expressed in moderate (one-third of the cases), with febrile seizures (more than half the time) are expressed to the maximum.

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