

Assessment of Hearing in Children with Cerebral Palsy

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Abstract

Introduction: The objective of this study is to identify the prevalence and nature of auditory analyzer pathology in children with different forms of infant cerebral palsy by recording otoacoustic emission and recording short latency brainstem auditory evoked potentials.

Materials and Method: The subject group consisted of 75 children, 40 (53%) males and 35 (47%) were females, ranging from 3 to 14 years of age with a confirmed diagnosis of cerebral palsy on the basis of a psycho-neurological hospital in Tashkent. (Uzbekistan). The examination of children was carried out by the following method: clinical examination of patients (general and otorhinolaryngological) and functional research method of the auditory analyzer.

Results: All children underwent acoustic impedancemetry, including tympanometry with determination of the type of tympanogram and acoustic reflex. The data obtained revealed a bilateral lesion of the peripheral part of the auditory analyzer. Bilateral sensorineural hearing loss was detected in 21-I-II degree, in 12-III degree and in 15-IV degree. Marked changes in the main parameters of BAEP were detected in the study of the stem structures of the auditory analyzer in children with cerebral palsy. Thus, disorganization, configuration disturbances of the component composition (I, III, V) were noted.

Conclusion: Thus, the study revealed a disorder of auditory function by sound-detecting type and justified the need for hearing correction in these children. Evaluation of auditory function made it possible to determine the level of auditory analyzer injury and localization of the process from the results of a complex, objective examination.

Keywords: *Cerebral palsy, hearing impairment, otoacoustic emission, brainstem auditory evoked potentials.*

Introduction

Cerebral palsy is a complex disease of the central nervous system, affecting not only body movement and muscle coordination¹, but leading also to complications such as hearing impairment², which in turn affects the delay in speech and mental development⁷.

In children with cerebral palsy, due to the delay of brain development⁴ or its pathology of development³, there may be a later formation of speech function, these

children understand the speech addressed to them,⁸ but their own speech is formed at a later date³. At the same time in pathogenesis of speech pathology the leading disorder can be damage of auditory analyzer, and disorder of hearing-motor conditional connections leads to insufficiency⁹ of motor component of speech in children with cerebral palsy, which further forms delay and underdevelopment of phonematic hearing¹⁰.

According to various sources, cerebral palsy develops in 2-3.6 cases per 1000 live births and is the

main cause of childhood neurological disability in the world¹¹. The prevalence of cerebral palsy in Uzbekistan is 3.7 cases per 1000 newborns (Mutalova Z.D. The structure of diseases of children with disabilities in Uzbekistan¹² under 16 years old (2012-2014) Institute of Health and Medical Statistics).

Among premature babies, the incidence of cerebral palsy is 1%. In newborns ¹³with a body weight of less than 1500 g, the prevalence of cerebral palsy increases to 5-15%, and with extremely low body weight - up to 25-30%¹⁴.

Thus, the leading and main ones in cerebral palsy are motor disorders, in case of change of muscle tone, coordination disorders, presence of pathological synsikinosis and senergia, involuntary movements¹⁴, as well as disorders of pose. Motor disorders have an adverse effect on the formation of mental, speech and auditory functions (Alieva Z.S., 2001,2005)¹⁶.

A frequent disorder in children with infantile cerebral palsy is speech disorder, the frequency of which according to some authors is between 65 and 85% (Aidinov M.B., Pravodina-Vinarskaya, 1959; Bohme, 1966), others from 70 to 80% of children (Semenova K.A., 1984, Badalyan L.O., 1988; Aliyeva Z.S., 2001, 2005)¹⁷.

Speech disorders can be associated with both deep mental retardation and the deafness bordering deafness. Often these speech disorders are combined ⁸.

In addition to damage to certain brain systems, secondary underdevelopment or later formation of those parts of the cerebral cortex that are extremely important for speech function and most strongly develop already in postnatal ontogenesis (premotor-frontal, dark-temporal regions of the cerebral cortex) plays an essential role in the genesis of speech disorders in these children (Klossovsky B.N., 1949; Megun G., 1960, Anokhin ILK., 1961). Since speech is a complex¹⁹ multi-level functional system²¹, correction of speech disorders in children with cerebral palsy is important,²² along with the study of auditory function²³. Due to the fact that²⁴ speech impairment may be due to hearing loss ²⁵.

Four main forms of cerebral palsy are distinguished depending on muscle tone disorders:

- Spastic,
- Ataxic

- Dyskinetic (subdivided into athetoid and dystonic forms)
- Mixed forms of cerebral palsy.

Cerebral palsy is also classified regarding the affected parts of the body:

- Hemiplegia (damage to one half of the body - right or left),
- Diplegia (paralysis that affects both halves of the body, but more of the legs),
- Tetraplegia (damage to the arms and legs).

According to (Semenova K.A., Makhmudova N.A., 1979) hearing impairment is noted in 10-40% of children with cerebral palsy, more often with a hyperkinetic form²⁶.

When a diagnosis is correct and made in a timely manner²⁷, it gives an opportunity, as early as possible, to begin correction of auditory disorders and integration of the child²⁸ into the speech environment, thus improving the quality of life of the baby²⁹.

The aim of this study was to determine the prevalence and nature of auditory analyzer pathology in children with different forms of infant cerebral palsy by recording otoacoustic emission and recording short latency brainstem auditory evoked potentials.

Materials and Method

The subject group consisted of 75 children, 40 (53%) males and 35 (47%) were females, ranging from 3 to 14 years of age. Clinical examination of children began with a thorough history of the child, starting from the moment of birth to the present period. The largest number of children 48, which amounted to 64% (Table 1), was with frequent forms of cerebral palsy (spastic diplegia).

Table 1: The distribution of the examined children in the form of cerebral palsy

Forms of cerebral palsy	Amount of children		Total
	M	D	
Spastic diplegia	27	21	48
Hemiparetic	9	3	12
Atonic-astatic	4	4	8
Hyperkinetic	1	4	5
Bilateral hemiplegia	2	-	2
Total	40	35	75

A significant part of the children's history had a combination of several risk factors that inevitably entail the addition of other factors and thereby sharply increase the likelihood of hearing loss.

Such a factor, for example, is birth weight less than 1500 g, which entails hypoxia, the need for prolonged mechanical ventilation and the use of ototoxic drugs. Thus, it was found that most of the examined children 53 (70.7%) were born prematurely (from 24 to 36 weeks of gestation), 48 (64%) of children with low body weight.

At 64.5% (31 people) had burdened obstetric history: a history of abortion had a 15 (31%) women, the share of abortions and dead born had by 10.4% and 12.5%, respectively. Analysis and statistical processing of 23 (48%) labor histories of pregnant women with various gestoses.

The examination of children was carried out by the following method: clinical examination of patients (general and otorhinolaryngological) and functional research method of the auditory analyzer. All children underwent acoustic impedancemetry, including tympanometry with determination of the type of tympanogram and acoustic reflex.

When registering tympanograms, 48 % of children received type «A», 31% - type «B» and 21% - type «C».

In order to differential diagnosis of conductive and sensorineural hearing loss, as well as to study the correlation of data obtained during acoustic impedancemetry depending on the condition of the middle ear, children were recorded caused by otoacoustic emission at the frequency of the distortion product. The stimulus intensity was used in the range from 50 to 70 dB, while the level of two tones was the same or varied by 5-10 dB. Based on measurements of the DPOAE amplitude obtained by presenting tones of different frequencies, a DP gram was automatically constructed — a graph of the dependence of the DPOAE amplitude on the tone frequency. For each point of the curve, the background noise level was also calculated. The amplitude of DPOAE exceeded the noise level by at least 3 dB.

One of the main objectives of this study was the differential diagnosis of auditory analyzer disorders. Currently, the use of acoustic auditory evoked potentials is of great importance to clarify the extent and location of lesions of the auditory analyzer. For this purpose,

children underwent an electrophysiological study of hearing using the method of recording short latency brainstem auditory evoked potentials- an assessment of the state of the stem structures of the auditory analyzer. When registering the BAEP, broadband clicks, tonal pulses with a rise frequency and a duration of 2 ms were used as sound stimuli; with a presentation frequency of 11/sec, 2,000 responses accumulated, analysis time - 20 ms; bandwidth - 30-1500 (12 dB per octave).

Results

The data obtained revealed a bilateral lesion of the peripheral part of the auditory analyzer. Bilateral sensorineural hearing loss was detected in 21 - I - II degree, in 12 - III degree and in 15 - IV degree.

Marked changes in the main parameters of BAEP were detected in the study of the stem structures of the auditory analyzer in children with cerebral palsy. Thus, disorganization, configuration disturbances of the component composition (I, III, V) were noted. The smoothness of the components was noted due to a decrease in the amplitude of the response by 2-2.5 times. The analysis of time parameters showed that, with a similar dependence of latency on changes in the intensity of the stimulus in children with cerebral palsy, in contrast to the norm, the time parameters of the main components of the BAEP (I, II, V) are significantly delayed: I - by 0.1 ± 0.06 ; III - by 0.2 ± 0.06 and by V - by 0.37 ± 0.07 ms. Peak intervals of the main components I - III; I - V; III - V are increased in comparison with the norm in the whole range of reactivity of BAEP. Studies have shown that the most pronounced peak-to-peak I - V intervals are increased by 0.18 ms compared to normal. In children with cerebral palsy with deep hearing impairment, a narrow dynamic range is observed, on average not exceeding 40-45 ms. An L - shaped dependence of latency on the increase in stimulus intensity was revealed; a significantly higher percentage of impaired volume function is noted.

Thus, the study allowed us to identify impaired auditory function in the sound-absorbing type in children with cerebral palsy. Assessment of auditory function allowed the results of a comprehensive, objective examination to determine the level of damage to the auditory analyzer and the localization of the process, as well as to conduct electro-acoustic rehabilitation of this category of children.

As you know, the leading and main in cerebral palsy are motor disorders that have an adverse effect on the formation of mental, speech and auditory functions [26]. A frequent violation in children with cerebral palsy is speech disorder, the frequency of which, according to some authors, ranges from 65 to 85% [1,3], while others from 70 to 80% of children [8,12,34]. Speech disorder may be delayed speech development (late formation of the motor component of speech, especially its sound-producing side), dysarthria (pseudobulbar, extrapyramidal, cerebellar, cortical). Speech disorders can be associated with both deep mental retardation and hearing loss bordering deafness. Often, these speech disorders are combined.

The study of the stem structures of the auditory analyzer in children with cerebral palsy, having normal thresholds of auditory sensitivity, revealed pronounced changes in the main parameters of the BAEP: disorganization, disturbances in the configuration of the component composition (I, II, V) were noted; smoothing of components was noted due to a decrease in the amplitude of the response by a factor of 2-2.5. Analysis of time parameters showed that, with a similar dependence of latency on changes in stimulus intensity in children

with cerebral palsy, in contrast to the norm, the time parameters of the main components of short evoked brain (I, II, V) significantly tightened: I - by 0.1 ± 0.7 ; III - by 0.18 ± 0.05 and by V - by 0.39 ± 0.08 ms. Peak intervals of the main components I - III; I - V; III - V are increased in comparison with the norm in the whole range of reactivity of SVP. Studies have shown that the most pronounced peak-to-peak I - V intervals are increased by 0.18 ms compared to normal. In children with cerebral palsy with deep hearing impairment, a narrow dynamic range is observed, on average not exceeding 40-45 ms. An L - shaped dependence of latency on the increase in stimulus intensity was revealed, a significantly higher percentage of impaired volume function (FCFN) was noted.

In a comparative aspect, the signal response in children with cerebral palsy was less mature. The amplitudes of the waves of auditory evoked potentials, as a rule, were smaller in comparison with normal values. In contrast, the peak-to-peak intervals in most cases corresponded to normal values. Table 2. presents the values of BAEP depending on the etiological factor of cerebral palsy.

Table 2: The values of BAEP depending on the etiological factor of cerebral palsy

Etiological factor	Number of patients	Peak Interval I-V	Amplitude V waves	% To I wave ratio
Very low weight	9	3.93 ± 0.25	0.35 ± 0.10	1.25 ± 0.66
Asphyxia	26	4.01 ± 0.24	0.28 ± 0.09	1.02 ± 0.67
Unknown etiology	12	4.07 ± 0.27	0.32 ± 0.12	1.14 ± 0.72
Control group	25	3.95 ± 0.18	0.37 ± 0.10	1.25 ± 0.61

In the history of the mother, we paid great attention to the course of pregnancy and childbirth. The presence of toxicosis in the mother, its course and duration, the use of ototoxic drugs during the pregnancy (aminoglycoside series, "loop" diuretics).

Discussion

Of the 9 children we examined with cerebral palsy, 4 children were born using cesarean section before the 30th week of gestational age, of which three children had birth weight less than 1500g. 2 children born on time had hyperbilirubinemia (bilirubin content of more than 20 mmol/l). With hemolytic disease of full-term newborns, there were 3 children.

A significant portion of the children have a history of a combination of several risk factors. Some of them inevitably entail the addition of other factors and thereby sharply increase the likelihood of hearing loss. Such a factor, for example, is birth weight less than 1500 g, which entails hypoxia, the need for prolonged mechanical ventilation and the use of ototoxic drugs.

In most cases, in children with cerebral palsy, the amplitude of I and V waves and the ratio of V waves to I were less than the average values characteristic of this age. Thus, the obtained values showed a significant difference in the amplitude of the V wave during cerebral palsy, due to the birth of very low body weight,

asphyxiation, and unknown etiology. The amplitude of the V wave in children born with a very low birth was slightly reduced, but did not significantly differ from the control group.

Some children showed poor identification of waves 2 and 4, sometimes even I waves. Basically, this observation was made in children with cerebral palsy of unknown etiology, who had deep damage to the central nervous system.

The results showed that there are no significant differences from the control group in the values of the peak intervals I-V, I-III and III-V in children with cerebral palsy, regardless of its etiology. There were also no significant differences in the interaural difference in the latencies of the V peaks on both sides of the interaural difference for the interval I-V, I-III and III-V. Compared with the control group, the interval I-V was slightly longer in children with cerebral palsy of unknown etiology. In children with cerebral palsy, against the background of very low body weight, the interval I-V was shortened.

As the obtained data show, a significant decrease in the amplitude of the V wave and, accordingly, the V / I ratio is observed in children who survived asphyxia at the beginning of life. There is also a tendency to shortening of the 1st wave, which leads to a relative increase in the V / I ratio. Of the 78 children with cerebral palsy, 21 (26.1%) had a significant decrease in the amplitude of the V wave, and 10 (12.5%) had a significant decrease V / I ratio. Absence of waves was noted in 14 cases (17.5%).

Only 10 children with cerebral palsy (12.5%) had a significant lengthening of the interval I-V, which was often accompanied by a significant decrease in the amplitude of wave V. Deviations in intervals I-III and III-V and ratios III-V / I-III were rare. An increase in intraural difference (6.3%) was noted in 5 (6.3%) cases. This increase was mainly due to the unilateral shortening of intervals III-V and IV (2 children with very low birth weight) or the unilateral extension of 2 intervals (2 children with unknown etiology of cerebral palsy).

In total, 48 out of 75 children with cerebral palsy had deviations in auditory evoked potentials, which manifested itself in a significant decrease in the amplitude of the V wave, a decrease in the V/I ratio, an increase in the IV interval, and the absence of I or more response waves. The most often seen deviations were manifested during the registration of the V wave,

which appeared by a decrease in its amplitude. In some children with cerebral palsy, more than one deviation from normative indicators was recorded. These children often, although not always, had profound disorders of the central nervous system.

The results showed a significant difference between children with cerebral palsy and the control group. The present study showed that the main changes in cerebral palsy are manifested in the form of depression of the signal and a decrease in the amplitude of the V wave, as a rule. These changes mainly reflect a decrease in the size, or synchronization of neural activity in the auditory part of the brain. These changes may be due to neurological abnormalities or be directly a manifestation of cerebral palsy. Summarizing, we can say that there is a depression of waves, including wave I. A decrease in the amplitude of the I wave is observed, accordingly, the V / I ratio increases. As a result, even with a significant decrease in the amplitude of the 5 wave, the V / I ratio changes little and remains within the normal range. This can largely explain why a significant decrease in the V / I ratio is less often detected compared to a decrease in the amplitude of the 5th wave. This result shows that, compared with the V / I ratio, the 5-wave amplitude is more sensitive when registering auditory evoked potentials with a reliable reflection of auditory function in clinical practice.

When assessing auditory evoked potentials, it should be taken into account that waves 2 and 4 are characterized by great variability and are less reliable than waves I, III, and V. In assessing the configuration of the curve, in some cases precipitation of individual components was noted. The curves with the loss of the first, third, and fifth peaks were not encountered in the analysis. The maximum loss occurred in the second, fourth and sixth components. According to the established opinion and literature data, it is these peaks that are distinguished with the least frequency. However, according to its own regulatory data, the secrecy of these peaks does not differ much from the secrecy of the rest, based on which we can conclude that configurational changes are quite common with spastic diplegia. The technique for recording auditory evoked potential includes mandatory monotonous audiometry, which allows you to get an idea of the state of auditory function. An increase in the auditory threshold above the laboratory norm was noted in 18 (30%) cases in 34 (28.3%) studies. That is, almost every third patient had a one-sided increase in the auditory threshold

The main trends in the parameters of the short-latency auditory evoked potential were a decrease in the amplitude and an increase in the latency of the components. A significant ($p < 0.05$) increase in latency was noted for the I, II, III, IV and VI components of the potential. An increase in absolute latencies per se cannot be a sign of conduction disturbance at the stem level, especially given how often disturbances in the function of the peripheral part of the analyzer were encountered. However, a significant increase in the inter-peak interval III – V indicates dysfunction of stem afferents at the bridge-mesencephalic level. The detected decrease in the amplitude of the I, II, V components of the potential ($p < 0.05$) is most likely a consequence of the dysfunction of the peripheral unit of the analyzer.

A fall in the amplitude V / I ratio below 0.75 was observed in 20%, below 0.5 - in 6.7% of patients in 5 (4.2%) studies. The analysis of peak-to-peak intervals indicates the truth of the revealed changes in the conductive ability of stem afferents. The analysis of amplitude relationships allows us to confirm the presence of a nuclear-dysfunctional component in the pathophysiological picture of spastic diplegia, however, the frequency of occurrence does not allow us to see in it the key mechanism of the pathogenesis of stem disorders present in the clinical picture of the disease. The revealed changes in the conductive properties of stem afferents contribute to the picture of the dysfunction of stem structures during spastic diplegia and can have residual demyelination nature.

Thus, the study revealed a disorder of auditory function by sound-detecting type and justified the need for hearing aids in these children. Evaluation of auditory function made it possible to determine the level of auditory analyzer injury and localization of the process from the results of a complex, objective examination.

Conclusion

1. The use of objective method for the study of hearing in children with cerebral palsy allows you to identify the nature and extent of hearing impairment.
2. The pathogenesis of cerebral palsy combines dysfunction of the nuclear apparatus of the brain stem and impaired conductive properties of stem afferents.
3. The study of hearing at an early age with the help of objective method helps to timely detect hearing impairment and delineation of deafness and hearing

loss from a number of diseases that delay speech development, which is an important link in the chain of rehabilitation measures aimed at correcting difficult - the structure of the defect in children with Cerebral palsy.

4. Our study indicated the need for an early (from the first days of life) and comprehensive objective examination of auditory function in children with cerebral palsy. Early diagnosis of the pathology of the auditory analyzer provides timely correction of auditory-speech disorders in children with cerebral palsy.

Authors' Contributions: The first author drafted the manuscript. All authors read and approved the final article.

Acknowledgements: Many thanks to the staff of the Clinical Ophthalmic Hospital of the Ministry of Health of the Republic of Uzbekistan for the cooperation and facilities they have created to conduct our research there. The patient kindly gave full written permission for this report. We are thankful for that.

Conflict of Interest: The authors declare that they have no competing interests.

Funding: No funding sources to declare.

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