



Auditory Pathologies in Children with Cerebral Palsy

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Abstract

Background: The location of lesions causing hearing loss in patients with cerebral palsy remains unclear.

Objectives: To evaluate the incidence and characteristics of auditory pathologies in children with various forms of cerebral palsy.

Methods: This prospective observational study enrolled 42 children with a confirmed diagnosis of cerebral palsy. All participants underwent comprehensive clinical examinations; including general and otorhinolaryngological assessments. Audiological evaluations were performed via analyzing brainstem auditory responses (ABR), including short-latency brainstem auditory evoked potentials, as well as, distortion product otoacoustic emission (DPOAE). Tympanometry with (classification of tympanogram types and assessment of acoustic reflexes).

Results: The findings demonstrated bilateral lesions in the peripheral portion of the auditory analyzer. Bilateral sensorineural hearing loss (SNHL) was identified in all affected children: 6 children in grade I (mild), 8 children in grade II (moderate), 10 children in grade III (severe), 18 children in grade IV (profound). Significant alterations in key parameters of brainstem auditory structures were observed, particularly in the wave components I, III, and V.

Conclusions: This study revealed significant auditory dysfunction in children with cerebral palsy, predominantly characterized by severe bilateral sensorineural hearing loss. The findings support the need for early hearing correction in this population and highlight the potential for identifying the level of auditory pathway involvement.

Keywords: Children; Cerebral Palsy; Sensorineural Hearing Loss; Auditory Brainstem Response; Otoacoustic Emission

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Introduction

Cerebral palsy (CP) is a group of non-progressive neurological disorders caused by injury to the developing brain, leading to motor impairment and frequently associated with sensory and cognitive deficits [1]. Hearing impairment is a recognized comorbidity in children with CP and can significantly affect speech, language development, and overall quality of life [2].

The exact localization of lesions responsible for hearing loss in CP remains unclear. Auditory dysfunction may arise from peripheral structures, such as the cochlea and auditory nerve, or from central components, including the brainstem and higher auditory pathways [3]. Objective audiological methods such as auditory brainstem response (ABR), otoacoustic emissions (OAE), and impedance audiometry provide reliable tools for evaluating auditory function, especially in children who cannot cooperate with behavioral testing [4].

CP is commonly associated with a spectrum of developmental disabilities. Besides motor abnormalities, a child with CP suffers from multiple handicaps like mental retardation, epilepsy, visual, hearing, speech, cognitive, and behavioral abnormalities, yet, there are few published studies on the prevalence of hearing loss in CP, as, the incidence of hearing loss was reported to be between 7% and 37.5%, with the majority of studies commenting only on sensorineural hearing loss (SNHL), therefore, lesions causing hearing loss potentially involve the organ of Corti, especially at the outer hair cells and the cochlear nerve [5].

Hearing loss, which is so commonly associated with CP, requires an audiological assessment for a definitive diagnosis, as, distortion product otoacoustic emissions (DPOAE), transient evoked otoacoustic emissions (TEOAE), brainstem evoked response audiometry (BERA), pure-

tone audiometry (PTA), impedance audiometry, cortical evoked response audiometry (CERA), and functional magnetic resonance imaging (fMRI) to identify and evaluate the hearing loss and make an endeavor to locate the site of lesion in such cases. children who are not responsive can be tested for hearing loss using an auditory evoked potential that measures the lowest possible sound level, which produces a brain wave in the children [6].

Although SNHL in children with CP has been known for more than 50 years, yet the site of lesion in these cases remains in controversy. Also, the assessment of hearing in CP patients has always been a difficult task to make any auditory stimulus in these patients. Even in those cases where hearing loss is established, the location of lesion causing hearing loss remains uncertain [7].

The auditory nerve and brainstem auditory sensory pathway's functional status can be assessed using BERA, which is a safe and effective method, while, drugs, other environmental circumstances, and states of awareness do not greatly change it [7].

This study aimed to evaluate the incidence and characteristics of auditory pathologies in children with cerebral palsy and to determine the level of auditory pathway involvement using electrophysiological and audiological assessments.

Patients and Methods

This prospective observational study included 42 children with a confirmed diagnosis of cerebral palsy and not assessed for hearing screening on birth were included.

All children underwent general clinical examination and otorhinolaryngological (ENT) examination, also they underwent a comprehensive audiological assessment including: Tympanometry: Assessment of middle ear function, tympanogram classification, and, also, the acoustic reflexes, moreover the Distortion Product Otoacoustic Emission (DPOAE) using "OtoRead – Screener, software version 7.65.01 with Thermal dot matrix line printer, Interacoustics, DK.- 5610 Assens, Denmark" for evaluation of cochlear outer hair cell function, and the Auditory Brainstem Response (ABR) using "Neuro-MEP-4 connection, Neurosoft Ltd., Ivanovo, 153032, Russia" for recording of short-latency auditory evoked potentials, focusing on waves I, III, and V to assess neural conduction along the auditory pathway. Data Analysis sensorineural hearing loss was classified into degrees I-IV according to standard audiological criteria. ABR wave abnormalities were analyzed to determine the level of auditory system involvement.

Inclusion criteria

Children with cerebral palsy attending Otorhinolaryngology outpatient unit or referred from pediatric outpatient department or with some antenatal/maternal, perinatal/intra-natal or postnatal history, and also, suspected to have hearing impairment/speech delay which suggestive of high-risk factors.

Exclusion criteria

The children with congenital anomalies of external ear, acute otitis media, ossicular chain abnormalities, perforated tympanic membranes, and chronic otitis media.

The evaluations were conducted to identify any external or middle ear abnormalities "structural abnormalities or conditions affecting the auditory system".

Statistical analysis

SPSS version 25 (Chicago, USA). Categorical variables were expressed as frequency and percentage, while mean \pm SD standard deviation was labelled for numerical variables. Chi-square test was applied to compare categorical variables among patients with and without hearing loss. P value $<$ 0.05 was considered to be statistically significance.

Results

Among 42 enrolled children with cerebral palsy, there are 19 boys (45.23%), and 23 girls (54.76%), aged between 1-12 years, with mean age was 8.23 ± 1.54 SD year. There was no significant difference between these values, as the P values were $>$ 0.05.

About 31 children (73.80%) were born by forceps delivery, and 11 (26.19%) were born by cesarean section, with a significant difference, as the P value=0.001.

The incidence of various forms of children with cerebral palsy shown in table 1, with no significant difference between these values, as the P values were $>$ 0.05.

Hearing loss characteristics

Bilateral sensorineural hearing loss (SNHL) was identified in all affected children: 6 children in grade I (mild), 8 children in grade II (moderate), 10 children: Grade III (severe), 18 children in grade IV (profound). These results showed a high prevalence of hearing impairment in children with cerebral palsy, table 2 revealed the distribution of sensorineural hearing loss severity in children with cerebral palsy.

Prematurity, as detected in 28 children (66.66%), together with the number of family history of maternal infections were significantly high as, seen in 24 children (57.14%), with P values $<$ 0.05. While, maternal tobacco uses were not significantly associated with hearing loss, with P values were $>$ 0.05.

Audiological findings

Tympanometry results were predominantly within normal limits, suggesting intact middle ear function and supporting a sensorineural origin of hearing loss. OAE testing revealed cochlear dysfunction in a substantial proportion of patients, indicating impairment at the level of the outer hair cells, as, it revealed in table 3.

ABR findings reported a significant abnormality observed in ABR waveforms: Wave I abnormalities suggested peripheral auditory nerve involvement. Waves III and V abnormalities indicated dysfunction within brainstem auditory pathways, as it shown in table 4.

Discussion

The incidence of various forms of children with cerebral palsy in

Table 1: Incidence of CP types.

Form of cerebral palsy	Children number	Percentage
Hypotonic	12	28.57%
Spastic diplegia	10	23.80%
Spastic quadriplegia	8	19.04%
Hemiplegia	6	14.28%
Ataxic	4	9.52%
Dystonic	2	4.76%
Total	42	100%

Table 2: Distribution of sensorineural hearing loss in children with cerebral palsy.

Degree of sensorineural hearing loss	Number of children	Percentage
Grade I (mild)	6	14.28%
Grade II (moderate)	8	19.04%
Grade III (severe)	10	23.80%
Grade IV (profound)	18	42.85%
Total	42	100%

Table 3: Summary of audiological findings.

Test method	Main finding	Interpretation
Tympanometry	Predominantly normal tympanograms	Normal middle ear function
Acoustic reflex	Reduced or absent in several cases	Suggestive of neural involvement
Otoacoustic emission (OAE)	Reduced/absent responses	Cochlear (outer hair cell) dysfunction
Auditory brainstem response (ABR) = Auditory nerve	Abnormal I wave	Peripheral (neural conduction) involvement
Auditory brainstem response (ABR) = Brainstem	Abnormal III, V waves	Central auditory pathway involvement

Table 4: Abnormalities of ABR waves in study population.

Site of generation	Observed abnormality	Clinical significance
Auditory nerve	Prolonged latency/reduced amplitude	Peripheral auditory dysfunction
Cochlear nucleus/brainstem	Delayed latency	Brainstem pathway involvement
Lateral lemniscus/midbrain	Markedly delayed or absent	Significant central auditory deficit

the current was almost similar to Kumar R, et al., [8] study. Also, the present study confirms that children with cerebral palsy are at high risk for bilateral sensorineural hearing loss, with severity of hearing loss, that highlights the importance of early detection, these results were consistent with other studies [6-8].

Mathur NN, et al., [11] detected that, children with CP who are BERA fail and OAE pass could have lesion at the spiral ganglion or brainstem or cochlear nerve, and those with BERA fail and OAE fail (39%) could have purely cochlear or cochlear and brainstem/nerve involvement, so, they concluded that, the prevalence of sensorineural hearing loss was calculated to be 41.5%, in most cases, the site of the lesion was found to be cochlea, as OAE was absent in most cases (83.5% of patients tested). OAE was found to be a less efficacious test as compared to BERA in detecting hearing loss.

The study done by Weir FW, et al., [12] concluded that hearing loss among children with CP could be of large degree of sensorineural loss, while the predisposition could be bilateral and the extent of hearing loss could be linked with severity of motor or neurological disability among children with CP.

Many studies, reported that the proportion hearing loss ranges between 4-13% among children with CP. All these studies exhibit that there lies a difference in the frequency of hearing loss among children with CP and the differences could be attributed to variations in the extent of functional impairment, motor types, etiology, age of the diagnosis and rehabilitation care among children with CP [13-15].

The combination of ABR and OAE provides complementary diagnostic information, allowing differentiation between cochlear and neural pathologies.

In Kalambe S, et al., [16] study, both OAE and BERA tests were comparable and statistically significant with p value of 0.0001. OAE has a high specificity and positive predictive value of 93.33% and 97.22% respectively and it has a low sensitivity and negative predictive value of 67.74% and 45.65% respectively.

A study performed by Nazir T, et al., [17] found that auditory Brainstem Response (ABR) “brain evoked response auditory (BERA)” became the gold standard test, which had a sensitivity of 87.7% (74.5%-94.9%) and a specificity of 74.5% (60.0%-85.2%), also, a negative predictive value of 86% (71.9%-94.3%) and a positive predictive value of 76.7% (63.2%-86.6%), the negative likelihood ratio was 6.08, while the positive likelihood ratio was 0.29 (0.18-0.46).

In the current study revealed that, the audiological findings reported the following: Tympanometry findings were consistent with predominantly normal middle ear function, suggesting a sensorineural rather than conductive pathology; Otoacoustic Emission (OAE) results indicated cochlear dysfunction in a significant proportion of patients, and, significant abnormalities were observed in main Auditory Brainstem Response (ABR) wave components; with wave I; as, it indicative of peripheral auditory nerve involvement, wave III and V; were reflecting dysfunction within brainstem auditory pathways. These abnormalities in ABR waves suggest combined peripheral and brainstem-level auditory impairment in children with cerebral palsy, as described in other studies [3, 8].

This supports earlier findings that perinatal and neurological insults can damage multiple levels of the auditory system.

OAE results further indicate cochlear involvement, particularly outer hair cell dysfunction, which is a key feature of sensorineural hearing loss [4].

Clinical Implications

Early identification of hearing impairment is essential for optimizing developmental outcomes. Objective audiological screening methods such as ABR and OAE are especially valuable in children with CP due to limited cooperation with behavioral tests [3, 4].

Timely intervention—including hearing aids or cochlear implantation—can significantly improve speech and language development, and identifying the level of lesion can also guide individualized rehabilitation strategies in children with CP [18].

Limitations of this study includes: small sample size, absence of a control group, lack of longitudinal follow-up. Future studies should include larger populations and assess long-term outcomes following intervention.

Conclusions

Children with cerebral palsy exhibit significant auditory dysfunction, predominantly bilateral sensorineural hearing loss. Combined use of ABR, OAE, and impedance audiometry enables accurate assessment of both peripheral and central auditory pathways. Early diagnosis and intervention are critical to improving communication and developmental outcomes.

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