# A STUDY OF BERA CHANGES IN ACUTE MENINGITIS CASES OF PAEDIATRIC AGE GROUP

*Sudhakar Rao M. S[1], Bharadwaj[2], Malige Rajkamal[3]*

*[1]Specialist, Department of ENT, Vijayanagara Institute of Medical Sciences, Bellary.*
*[2]Postgraduate, Department of ENT, Vijayanagara Institute of Medical Sciences, Bellary.*
*[3]Postgraduate, Department of ENT, Vijayanagara Institute of Medical Sciences, Bellary.*

**ABSTRACT**

**BACKGROUND**

Hearing impairment due to acute meningitis among the high-risk cases is a dreadful condition affecting development and maturation of auditory system which interferes with normal development of speech and language. Early detection of this hearing impairment and management is the key for avoiding this morbidity.

The aim of the study is to assess the status of hearing impairment in paediatric patients who suffered acute meningitis.

**MATERIALS AND METHODS**

A prospective BERA study in children who were treated and discharged for acute meningitis from paediatrics department conducted in the otorhinolaryngology department, VIMS, Bellary, Karnataka, India, from December-2016 to July-2017 on simple random basis of selection in both sexes.

**RESULTS**

This prospective study statistically shows that there are significant BERA changes noted in acute meningitis children having variation in the graph peaks & inter wave latencies, suggesting varying degrees of hearing loss with significant percentage of disability.

**CONCLUSIONS**

Hearing is not a visible disability. It commonly goes undetected until it affects the child's communication in the form of speech and language or performance at home, school or in the society. This emphasizes the need for screening/detecting the cases treated for acute meningitis for the hearing impairment as well as any other high risk paediatric case, as early intervention helps the child in acquiring better speech language and communication as personality development and also it helps in social, and vocational rehabilitation.

**KEYWORDS**

BERA, Meningitis, Wave Latencies, SNHL.

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## BACKGROUND

Normal hearing is essential for a child to acquire normal language and speech skills. The rehabilitation of a deaf child should begin as early as possible. But usually, diagnosis of hearing impairment is made late.[1] Twenty percent children with bilateral profound hearing loss have acquired deafness. Out of these 90% are due to bacterial meningitis. Nadol et al studied that 5-40% of all childhood hearing impairment is due to bacterial meningitis.[2]

Sensorineural Hearing Loss (SNHL) is considered the most serious complication of bacterial meningitis in children. Given that SNHL in childhood may lead to several potentially long-term complications, including speech and language delay, poor academic performance, and impaired psychosocial adjustment, early identification of such hearing loss is imperative.[3,4] Early diagnosis of hearing impairment is important as the rehabilitative procedure can be started early which aids in speech and language development.

Brainstem Evoked Response Audiometry (BERA) is accurate and sensitive investigation for diagnosis of lesions in VIII nerve and auditory pathway in brainstem. BERA is a noninvasive technique, easily recordable and cost-effective method for diagnosing retrocochlear pathology. It also provides rapid and efficient way to screen for hearing loss in children.

So, in the present study an attempt has been made to assess the status of hearing impairment in paediatric patients who suffered acute meningitis using BERA as audiological tool.

## MATERIALS AND METHODS

This is a prospective study of 31 children which was conducted in the otorhinolaryngology and head and neck department, VIMS, Bellary, Karnataka, India. This study is done using simple random basis of patient selection, in children of both sexes who were treated and discharged for

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*Corresponding Author:*
*Dr. Bharadwaj,*
*Room No. 113, Department of ENT,*
*Vijayanagara Institute of Medical Sciences,*
*Ballari-583104.*
*E-mail: bhayriap@gmail.com*
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acute meningitis from department of paediatrics, VIMS, Bellary between December-2016 and July-2017.

**Inclusion Criteria**

- All the paediatric patients between 0-14 years who were diagnosed and treated for acute meningitis from the department of paediatrics, within 1 week of discharge.

**Exclusion Criteria**

- Patients in the acute stage of meningitis.
- While the patient is still undergoing treatment for meningitis in hospital.

BERA was recorded by standard method, within a week after the child recovering from acute meningitis and discharged from paediatric department. All children were sedated with triclofos; dosage according to their age was given before recordings were made. The wave forms were recorded by far field technique using silver disc electrodes. The active electrode was fixed on the forehead, whereas the reference electrode was fixed on the ipsilateral mastoid area and the ground electrode was fixed on the mastoid area on the side opposite to the ear being tested. Monaural alternating clicks were delivered to the ear under test at the rate of 11/sec.

A hearing level of 40 dB was taken as normal for the screening purposes. Both ears were' tested separately. Patients having absence of waves, poor morphology of waves and abnormally prolonged latencies, especially of wave V were labelled as abnormal. The absolute latencies of wave I, III and V and interpeak latencies I-III, I-V, III-V were recorded, and data was statistically analysed.

**Ethics**

This study was approved by the Ethical committee and institution review board of Vijayanagara Institute of Medical Sciences, Bellary under Rajiv Gandhi University of Health Sciences, Bengaluru, Karnataka, India.

**Study Analysis**

Statistical analysis was done with IBM SPSS Version 22 for Windows. Qualitative data was represented in the form of frequency. Association between qualitative variables was assessed by Chi Square test. Quantitative data was represented in the form of Mean & Standard deviation. Inter-group comparison was done with unpaired t test. A p value of <0.05 was considered as statistically significant.

**RESULTS**

This study included 31 patients between the age of 0 to 14 years, with 20 males and 11 females. Among 31 patients affected with meningitis, 17 children were affected with SNHL. 14 children were found to have normal hearing.

Most common affected age group was 6-10 years having 11 (64%) affected children followed by 0-5 years age group with 4(24%) affected children and 11-15 years age group with 2(12%) affected children as shown in table no 1.

| Age in Years | Affected (n=17) | Normal (n=14) | Chi Square Test |
|---|---|---|---|
| 0-5 | 4 | 8 | 8.12, P<0.01, Sig |
| 6-10 | 11 | 2 | |
| 11-15 | 2 | 4 | |

***Table 1. Distribution of Patients Based on the Age Group***

| Sex | Affected (n=17) | Normal (n=14) | Chi Square Test |
|---|---|---|---|
| Male | 9 | 11 | 2.23, P<0.138, NS |
| Female | 8 | 3 | |

***Table 2. Distribution of Patients Based on Gender***

Male and female children are equally affected (9 males and 8 females) with slight male predominance. (Table 2)

| Right | | | |
|---|---|---|---|
| **Wave Latency** | **Affected** | **Normals** | **Unpaired t Test** |
| I | 2.31 ± 0.61 | 1.69±0.25 | 3.55, P<0.0001, HS |
| III | 4.43 ± 0.49 | 3.75 ± 0.22 | 4.69, P<0.000, HS |
| V | 6.85 ± 0.77 | 5.86 ± 0.26 | 4.54, P<0.000, HS |
| I - III | 2.28 ± 0.51 | 2.06 ± 0.45 | 1.38, P<0.178, NS |
| III - V | 2.36 ± 0.45 | 2.04 ± 0.27 | 2.23, P<0.03, S |
| I - V | 4.64 ± 0.85 | 4.12 ± 0.37 | 2.18, P<0.03, S |
| S= Significant, HS = Highly Significant, NS= Not Significant | | | |

***Table 3. Comparison of Wave Latencies in Affected with Normal Patients in Right Ear***

| Left | | | |
|---|---|---|---|
| **Wave Latency** | **Affected** | **Normals** | **Unpaired t Test** |
| I | 2.51 ± 0.49 | 1.84 ± 0.42 | 3.98, P<0.000, HS |
| III | 4.53 ± 0.49 | 3.71 ± 0.45 | 4.40, P<0.000, HS |
| V | 7.18 ± 1.07 | 5.85 ± 0.45 | 4.29, P<0.000, HS |
| I - III | 2.09 ± 0.64 | 1.87 ± 0.31 | 1.17, P<0.254, NS |
| III - V | 2.62 ± 0.79 | 2.07 ± 0.27 | 2.39, P<0.02, S |
| I - V | 4.49 ± 1.31 | 3.95 ± 0.26 | 1.52, P<0.141, NS |
| S= Significant, HS = Highly Significant, NS= Not Significant | | | |

***Table 4. Comparison of Wave Latencies in Affected with Normal Patients in Left Ear***

In the affected right ears, all the wave latencies (Wave I, Wave III, Wave V) and the interwave latencies (III-V and I-V) are prolonged except I-III interwave latency. (Table 3) And in the left affected ears, all the wave latencies (Wave I, Wave III, Wave V) and the interwave latencies (III-V) are prolonged except I-III and I-V interwave latencies. (Table 4)

When compared with right and left side, in males, all the wave latencies (Wave I, Wave III, Wave V) and the interwave latencies (III-V and I-V) are prolonged except I-III interwave latency on the right side and all the wave latencies (Wave III, Wave V) except wave I and the interwave latencies (III-V and I-V) are prolonged except I-III interwave latency on the left side are affected. (Table 5)

| Male patients | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Wave latency** | | **Right** | | | **Left** | | |
| | | **Mean** | **Std. Deviation** | **Unpaired t test** | **Mean** | **Std. Deviation** | **Unpaired t test** |
| I | Affected | 2.40 | 0.68 | 3.02, P<0.007, HS | 2.19 | 0.42 | 1.59, NS |
| | Normals | 1.75 | 0.19 | | 1.86 | 0.45 | |
| III | Affected | 4.26 | 0.48 | 3.13, P<0.006, HS | 4.59 | 0.58 | 3.4, P<0.003, HS |
| | Normals | 3.78 | 0.17 | | 3.75 | 0.48 | |
| V | Affected | 6.95 | 0.92 | 3.70, P<0.002, HS | 7.32 | 1.27 | 3.35, P<0.004, HS |
| | Normals | 5.88 | 0.25 | | 5.92 | 0.49 | |
| I-III | Affected | 2.10 | 0.43 | 0.56, NS | 2.29 | 0.67 | 1.75, NS |
| | Normals | 2.03 | 0.26 | | 1.88 | 0.34 | |
| III-V | Affected | 2.48 | 0.53 | 2.37, P<0.03, S | 2.76 | 0.94 | 2.25, P<0.03, S |
| | Normals | 2.03 | 0.30 | | 2.09 | 0.29 | |
| I-V | Affected | 4.77 | 0.86 | 2.55, P<0.02, S | 5.05 | 1.47 | 2.38, P<0.02,S |
| | Normals | 4.05 | 0.34 | | 3.98 | 0.28 | |
| S=Significant, HS=Highly Significant, NS=Not Significant | | | | | | | |

***Table 5. Comparison of Right and Left Side in Male Patients***

In females, Wave III and Wave V are prolonged on the right side and all the wave latencies (Wave I, Wave III, Wave V) are prolonged on the left side without affecting interwave latencies. (Table 6)

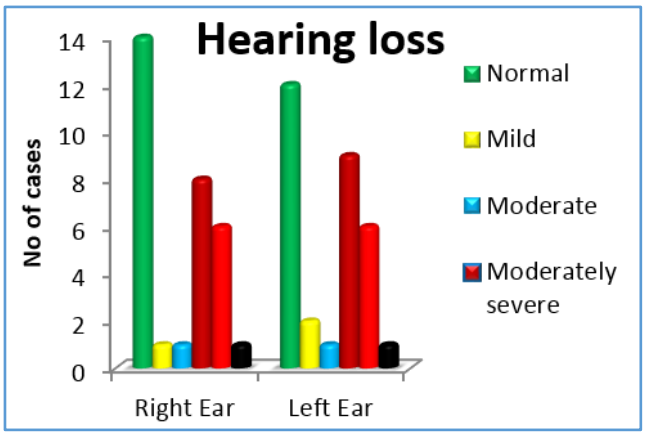
| Female patients | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Wave latency** | | **Right** | | | **Left** | | |
| | | **Mean** | **Std. Deviation** | **Unpaired t test** | **Mean** | **Std. Deviation** | **Unpaired t test** |
| I | Affected | 2.21 | 0.53 | 2.12, NS | 2.82 | 0.34 | 4.80, P<0.001, HS |
| | Normals | 1.49 | 0.39 | | 1.74 | 0.33 | |
| III | Affected | 4.66 | 0.46 | 3.19, P<0.01, S | 4.41 | 0.30 | 3.72, P<0.01, S |
| | Normals | 3.67 | 0.40 | | 3.54 | 0.31 | |
| V | Affected | 6.73 | 0.62 | 2.48, P<0.03, S | 7.04 | 0.91 | 2.67, P<0.02, S |
| | Normals | 5.78 | 0.34 | | 5.57 | 0.22 | |
| I-III | Affected | 2.52 | 0.54 | 0.92, NS | 1.70 | 0.37 | 0.243, NS |
| | Normals | 2.15 | 0.59 | | 1.80 | 0.26 | |
| III-V | Affected | 2.21 | 0.31 | 0.48, NS | 2.33 | 0.31 | 1.35, NS |
| | Normals | 2.11 | 0.14 | | 2.03 | 0.25 | |
| I-V | Affected | 4.49 | 0.87 | 0.36, NS | 3.92 | 0.88 | 0.164, NS |
| | Normals | 4.29 | 0.49 | | 3.84 | 0.11 | |
| S=Significant, HS=Highly Significant, NS=Not Significant | | | | | | | |

***Table 6. Comparison of Right and Left Side in Female Patients***

Majority of affected children lie in moderately severe hearing loss group (8 in right ear and 9 in left ear) followed by severe hearing loss (6 each in both ears), mild hearing loss (1 in right ear and 2 in left ear), moderate hearing loss (1 each in both ears) and profound hearing loss groups (1 each in both ears). (Graph 1).

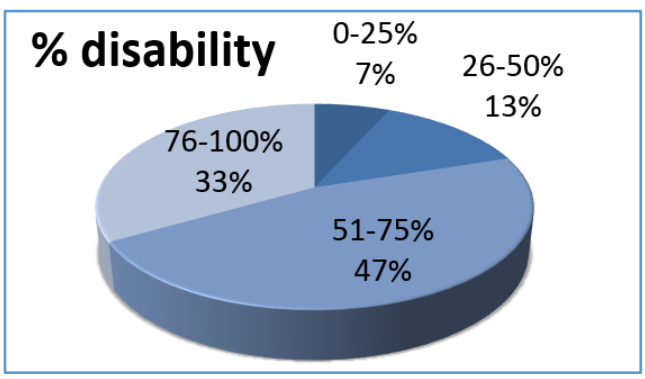
| Hearing Loss | Right | Left |
|---|---|---|
| Normal | 14 | 12 |
| Mild | 1 | 2 |
| Moderate | 1 | 1 |
| Moderately severe | 8 | 9 |
| Severe | 6 | 6 |
| Profound | 1 | 1 |

***Table 7. Distribution of Patients based on Degree of Hearing Loss***




***Graph 1. Distribution of Patients Based on Degree of Hearing Loss***

46.7% (7 children) of affected children lies in 51-75% of disability, 33.3% (5 children), 13.3% (2 children) and 6.7% (1 child) of affected in children in 76-100%, 26-50% and 0-25% of disability respectively. (Graph 2)




***Graph 2. Graphical Representation of Percentage of Patients with Disability***

**DISCUSSION**

The exact manner in which organisms gain access to the inner ear remains uncertain. However, bacterial meningitis is believed to precipitate SNHL by way of extension of meningeal infection from the subarachnoid space along the eighth cranial nerve, the periotic duct, and the cochlear aqueduct.[5]

As such, labyrinthitis with transient and partial hearing loss may ensue. However, labyrinthitis of a serous or toxic nature may cause permanent and severe damage to the inner ear. Otopathologic studies in cases of fatal bacterial meningitis have demonstrated initial involvement of the perilymphatic spaces, with eventual involvement of the endolymphatic spaces.[6]

Cochlear pathology is established successively as formation of serofibrinous exudate, infiltration of inflammatory cells, and formation of granulation cells. If infection is unresolved, varying degrees of damage, ranging from alterations in the stereocilia of hair cells to complete loss of the organ of Corti to labyrinthitis ossificans, result,[6] in which the infectious process in the cochlea produces endosteal reaction, most commonly involving the basal scala tympani.[7,8,9,10]

Thus, permanent hearing loss from meningitis occurs primarily at the cochlea with loss of the organ of Corti and is believed to occur early in the course of the illness.[8] Bacterial meningitis may also directly damage the auditory nerve and central neural pathways, although retrocochlear pathology is relatively rare.[11]

In our study, we found moderately severe HL in 8 patients with right ear and 9 patients with left ear, and severe hearing loss in 6 patients each of both ears. HL which was bilateral in 15 patients and unilateral in 2 patients.

We found that bacterial meningitis causes unilateral as well as bilateral Sensorineural hearing loss. This observation has also been made by other authors .[12,13,14]

More severe hearing loss was noted with bilateral involvement of auditory pathway. Only 10% cases having moderate degree of sensorineural loss had bilateral involvement, whereas all the children with severe degree of sensorineural loss had bilateral involvement. No gender predilection was noted ($p > 0.05$). Similar findings were reported by otllers.[3,14,15]

Comparisons of BERA in all age groups showed a statistically significant delay in absolute latencies of wave I, III & V. Similarly, there was statistically significant delay interpeak latencies III-V and 1-V in all the age groups. Thus, the probable site of lesion is in the cochlea, auditory nerve, cochlear nucleus and superior olivary complex.

Hecox[16] recorded the same findings in BERA due to bacterial meningitis, however, Nadol J.B. et al has shown that the site of involvement in bacterial meningitis is the cochlea[14] whereas others suggest a varying degree of retrocochlear involvement.[17]

The probable causes of sensorineural hearing loss following bacterial meningitis are direct infection of labyrinth via cochlear aqueduct[14,18,19] toxic or serous labyrinthitis[14,19] small vessel thrombophlebitis, increased intracranial pressure,[18] involvement of 8$^{th}$ nerve in internal auditory meatus causing perineuritis[18] and cortical necrosis or hypoxia which may damage the central auditory pathway and potentially result in central auditory imperceptions.[18]

If normal hearing is demonstrated after the first few days of hospitalization it is highly unlikely to change (i.e., develop into permanent sensorineural hearing loss).

Although hearing loss may improve, fluctuate, or deteriorate, the majority of hearing losses are likely to be stable. If hearing fluctuates, it can take a year or more to stabilize. If improvement in hearing levels are seen it is most likely to occur in children with mild to moderate sensorineural hearing loss rather than severe to profound sensorineural hearing loss. If hearing loss is severe, profound improvement is possible, but unlikely.

Development of effective antibiotics have really decreased meningitis mortality, but deafness and other neurological sequelae are still morbid complications. HL may easily be overlooked because of the serious course of bacterial meningitis. HL causes delay in speech and social development in children, and some children are misdiagnosed as mentally retarded or schizophrenic.

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## CONCLUSION

As hearing is not a visible disability, this emphasizes the need for screening/detecting the cases treated for acute meningitis for the hearing impairment as any other high risk paediatric case.

Hearing loss commonly goes undetected until it affects the child's communication in the form of speech and language or performance at home, school or in the society.

Early intervention helps the child in acquiring better speech language and communication as well as personality development. BERA being a cost effective screening tool, it should be made a mandatory follow up investigation in meningitis treated patients in order to reduce the disability (hearing loss) in children.

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