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RESEARCH ARTICLE

COMPARITIVE STUDY IN DETECTION OF SEVERE HEARING LOSS IN DEVELOPMENTALLY RETARDED CHILDREN USING BRAINSTEM-EVOKED RESPONSE AUDIOMETRY AND CONVENTIONAL AUDIOMETRY

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ABSTRACT

Background: This study was taken up to compare the hearing threshold in developmentally retarded children with severe hearing loss using conventional audiometry and brain stem evoked response audiometry.

Method: It was a Cross sectional, comparative study involving 20 developmentally retarded children in the age group of 6-12 yrs of age. Sample size was 20. Using BERA the hearing threshold in decibles (dB) of each ear was found seperately (Based on appearance of wave V at minimum stimulus intensity). Pure Tone Audiometry was used to measure hearing acuity over a range of frequencies (500 – 6000 Hz). The results were plotted on an audiogram, which displayed the auditory threshold at each frequency for each ear.

Result: The comparision report between BERA and PTA showed that 55% of cases had an agreement between the two (BERA and PTA) findings. 30 % showed no agreement between the 2 testing methods (BERA and PTA). In 15% of the cases estimation of hearing threshold could be made only by BERA test. Out of this 15% cases, 5% cases showed inconclusive PTA and the rest (10%) showed no response by PTA. The comparative finding of hearing threshold using Mann Whitney U Test as regards to PTA and BERA was found to be significant.

Conclusion: This indicates that BERA can provide a more conclusive information as compared to PTA regarding hearing threshold in severely deaf developmentally retarded children.

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INTRODUCTION

Hearing loss is a major public health issue and is the third most common such affliction after arthritis and heart disease (Clinical Policy Title, 2006). Hearing loss and deafness are global issues that affect at least 278 million people worldwide. Two-thirds of these people live in developing countries (Tucci, 2010). Early detection of hearing loss is one of the first prerequisite in the field of audiology. The commonest childhood handicaps is hearing loss and with a large chunk of its burden lies in developing countries like India; so this issue needs to be addressed. A hearing loss occurring early in life can have a major impact on speech and language development. Even a mild hearing loss during the first 3 years of life can adversely affect a child's development in areas that rely on auditory input (Alberti, 1983).

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Pure tone audiometry (PTA) is the key hearing test used to identify hearing threshold levels of an individual, enabling determination of the degree, type and configuration of a hearing loss. Thus, providing the basis for diagnosis and management. PTA is a subjective, behavioural measurement of hearing threshold, as it relies on patient response to pure tone stimuli. PTA provides ear specific thresholds, and uses frequency specific pure tones to give place specific responses, so that the configuration of a hearing loss can be identified (Sindhusake, 2001). PTA is described as the gold standard for assessment of a hearing loss. But, how accurate is PTA at classifying the hearing loss of an individual, in terms of hearing impairment and hearing disability? Hearing impairment is defined by theWorld Health Organisation (WHO) as a hearing loss with thresholds higher than 25db in one or both ears. The degree of hearing loss is classified as mild, moderate, severe or profound (Deafness and hearing loss Fact sheet N°300). Although widely used and fairly reliable in normal children, behavioural tests have their limitations when administered to a developmentally retarded paediatric

population. Further, behavioural tests, while measuring the lowest stimulus intensity to which response occurs, often do not provide an accurate picture of auditory threshold (McCormick, 1994). Brainstem Evoked Response Audiometry (BERA) is an objective test to understand the transmission of electrical waves from the VIIIth cranial nerve to the brainstem, in response to click sounds given through the ear. BERA is an effective tool that can be used for various screening for hearing loss in newborns, infants and other young children. There are no known risks of undergoing Brainstem Evoked Response Audiometry. In a developmentally retarded child, sustaining the child's attention is even more challenging. Response assessment is further hampered by concomitant motor disability like spasticity and involuntary movements. When results using these tests are inconsistent after two or three trials, it may become necessary to abandon further testing in favour of BERA (McCormick, 1994). In a study by Rakhi Kumari *et al* 2016, out of total of 105 cases in 62 cases (59.05%) the findings of both BOA and BERA tests were similar but in 43 cases the findings of both tests were not similar. In total 18 cases (17.14%) diagnosis of severe hearing loss could be made by BERA test only because of in 10 cases there was inconclusive BOA finding and in 8 cases there was no response in BOA test (Rakhi Kumari, 2016). Hence this study was planned to study developmentally retarded children with severe hearing loss using conventional audiometry and brain stem evoked response audiometry. We hypothesised that either both are equally effective (null) or that, BERA is better than conventional Audiometry (Alternate).

Research question

Is PTA sufficient in accurate detection of hearing threshold in DR children in the age group of 6-12 years with severe hearing loss as compared to BERA?

Aim

To study the severe hearing loss in developmentally retarded children using brainstem-evoked response audiometry and conventional audiometry.

Objective

- Determination of hearing threshold using Pure tone audiometry (PTA) in developmentally retarded (DR) children.
- Determination of hearing threshold using brainstem-evoked response audiometry (BERA) in DR children.
- To compare the detection of hearing threshold using PTA and BERA in DR children.

MATERIALS AND METHODS

Setting- Electrophysiology dept, AVBRH, Sawangi, Meghe, Wardha.
Design- Cross sectional, comparative study.
Sample size – 20.
Research plan- As detailed below, the study was undertaken, after IEC clearance.
Study protocol

Inclusion criteria

- Children between 6-12 yrs of age, visiting AVBRH hospital.
- Children diagnosed as cerebral palsy, birth asphyxia, microcephaly, hydrocephalous, history of seizures, congenital cataract, hyperbilirubinemia at birth requiring phototherapy.
- Cooperative DR children in this age group.
- Parents giving consent to the procedures.

Exclusion criteria

- Neonates, infants and children less than 6 years.
- All conditions other than mentioned above.
- Non- cooperative DR children in this age group.
- Children on ototoxic drugs.
- Non consenting parents.

Procedure of BERA

A. Instrument used- Polyright using Neuro-MeP.NET (Version 3) software.

A1- Technical specification used for the procedure

- Channels - single channel BAEP.
- Sensitivity - 0.5 μV / div.
- High cut filter – 2000 Hz.
- Low cut filter – 100 Hz.
- Sweep speed – 2 ms/div.
- Input impedence - < 5 K ohms.
- A/D converter – 14 bit analog – digital conversion.
- Number of averages -2000.

A2- Auditory stimulator

- Type – TA01 Headphone.
- Stimulus –click.
- Frequency- 2000 Hz.
- Intensity used – 30 dB SPL to 110 dB SPL.
- Presentation – Lt and Rt ear monaural.
- Click duration – 100 μs square wave clicks of alternating polarity.
- White noise – contra lateral masking by 30 dB less than stimulus intensity.

A3- Placement of electrodes

The monaural montage i.e Cz – M_1 / M_2 is used:

- Cz (vertex) = Reference or positive electrode.
- Fpz/Fz (nasion) =Ground.
- M_1/M_2 (mastoid) = Active or Recording electrode.

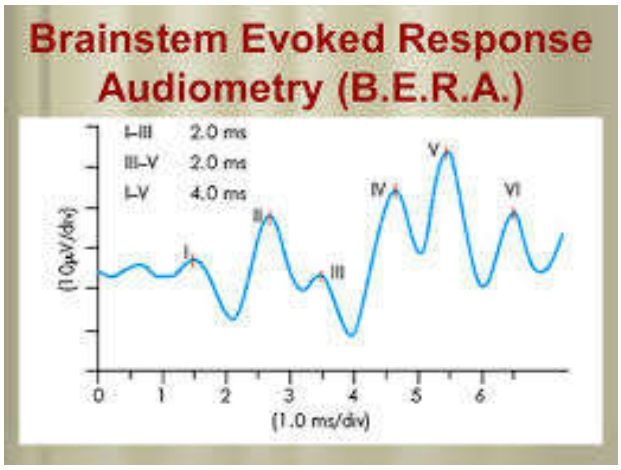
Electrical activities were recorded with silver electrodes (Ag/Agcl) placed on vertex C_2 and Mastoid M_1 or M_2 after clearing the area with acetone alcohol and applying conductive paste over there. Ground electrode were placed at the nasion (F_2). Potentials were evoked during resting and in few cases by sedation with Pedicloryl (Trichofos), by means of monaural stimulation with clicks of alternating polarity (ABR result is not affected by sedation or general anesthesia). The stimulation was first applied during a 2 min period of adaptation, preceeding the recording. Then intensity was decreased from 110dB down by 10 dB at each step until wave V formation was clearly seen . This was usually up to

90dB and in some cases upto 70dB. Rate of stimuli was 11.1/sec. The clicks were released from earphone of Neuro-MeP.NET, in an isolated room. The ear not being tested was masked with white noise 30dB below the intensity of stimulus. A total of 2000 stimulations was averaged and the process was repeated at least once to ensure reproducibility of the responses.

Parameters for interpretation

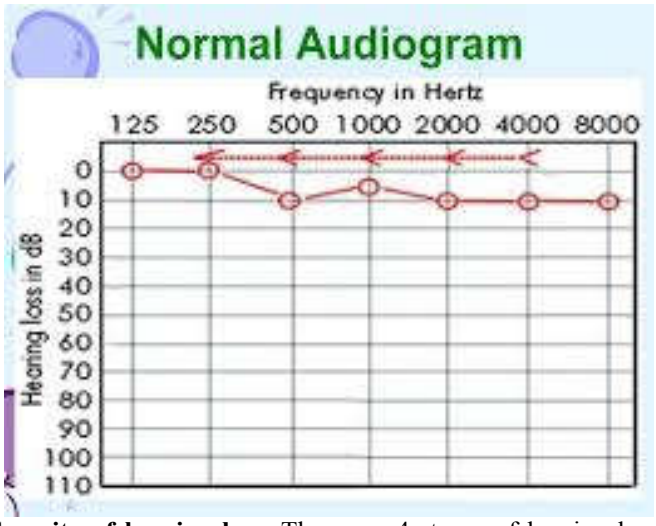
All the parameters were compared at 70 dB stimulus intensity level.

- Hearing threshold in decibles(dB) of each ear seperately (Based on appearance of wave V at minimum stimulus intensity).



Procedure Pure Tone Audiometry (PTA)

PTA or pure tone audiometry is a hearing test accepted worldwide as a standard protocol for determining hearing levels or hearing loss. Its a behavioural test used to measure hearing acuity over a range of frequencies. At each frequency there is a process by which the sound level is gradually decreased until the sound cannot be heard; the sound level is then increased until it can just be heard and, after a defined number of repetitions, this is then recorded as the auditory threshold. The results are plotted on an audiogram, which displays the auditory threshold at each frequency for each ear.



Severity of hearing loss: There are 4 stages of hearing loss, mild, moderate, severe and profound .

The average of audiogram was determined by calculating an average of the Air conduction thresholds obtained at 500Hz, 1000Hz and 2000Hz. Following are the hearing loss degrees:

- If this average falls between 0dB to 25dB then hearing is normal.
- If this average falls in between 25dB to 40dB then mild hearing loss.
- Between 41dB to 70dB it is moderate loss.
- Between 71dB to 90dB it is severe loss.
- Above 90db it is profound hearing loss.

Statistical analysis

Statistical analysis was done by using descriptive and inferential statistics using Kolmogorov Smirnov Z Test and Mann Whitney U test and software used in the analysis were SPSS 22.0 version and Graph Pad Prism 6.0 version. $p<0.05$ was considered as level of significance.

Observation

Table 1. Profile of study subjects (N=20)

Sr No.	Variables	Number of cases	Percentage
1	Gender		
	Males	9	45%
	Females	11	55%
2	Age group in years		
	6-8 yrs	8	40%
	9 -12 yrs	12	60%
3	Socioeconomic status		
	Lower class	16	80%
	Middle class	4	20%
4	Associated condition		
	Cerebral palsy	14	70%
	Birth asphyxia	2	10%
	Seizure history	2	10%
	Stunted growth	2	10%

Table 2. Hearing threshold using Pure tone audiometry (PTA) , (N=20)

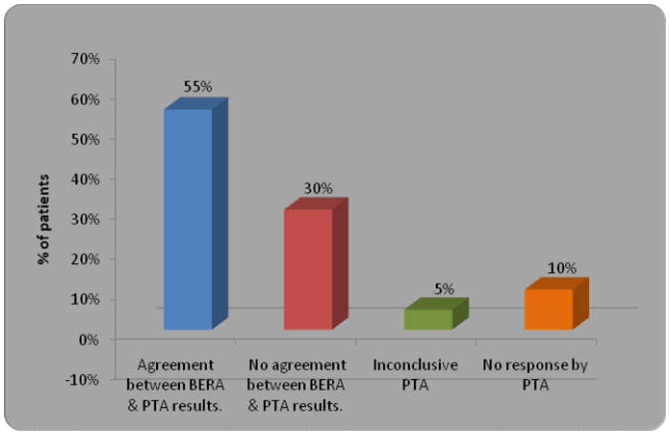
Sr No.	Hearing threshold	Number of cases	Percentage
1	≥100 dB	7	35 %
2	90 dB	3	15%
3	70 dB	4	20 %
4	Inconclusive finding	6	30%

Table 3. Hearing threshold using BERA, (N=20)

Sr No.	Hearing threshold	Number of cases	Percentage
1	≥100 dB	4	20%
2	90 dB	7	35%
3	80 dB	4	20%
4	70 dB	5	25%

RESULT

In this study 55% of the study subjects were female. 40% of the subjects were in the age group of 6 – 8 years and 60 % were in the 9 – 12 years age group. Majority of them (80%) were from low socioeconomic class. The associated condition were cerebral palsy, mental retardation, history of birth asphyxia, history of seizure and stunted growth (Table 1). Table 2 shows the report of Pure tone audiometry findings.



Graph 1- Comparision of hearing threshold using PTA and BERA

Table 4. Comparison of hearing threshold using PTA and BERA

Mann Whitney U Test

	N	Mean	Std. Deviation	Std. Error Mean	z-value	p-value
BERA	19	82.10	11.34	2.60	2.33	0.019,S
PTA	14	92.14	12.45	3.32		

Maximum cases were having a hearing threshold ≥ 100 dB (35%). 15% of the subjects had a hearing threshold of 90 dB and in 20% of the subjects, the hearing threshold was 20%. The study showed inconclusive finding for 30 % of the cases. Table 3 depicts the hearing threshold as detected by BERA. Maximum number of cases (35%) had a hearing threshold of 90 dB. Equal percentage of subjects (20%) were seen having a hearing threshold of 80dB and ≥100dB. 25% of the subjects had a hearing threshold of 0dB. Graph 1 shows the comparision report between BERA and PTA. 55% of cases had an agreement between BERA and PTA findings. 30 % showed no agreement between the 2 testing methods (BERA and PTA). In 15% of the cases estimation of hearing threshold could be made only by BERA test. Out of this 15% cases, 5% cases showed inconclusive PTA and the rest (10%) showed no response by PTA. The comparative finding of hearing threshold using Mann Whitney U Test as regards to PTA and BERA was found to be significant as seen from Table 4. This indicates that BERA can provide a more conclusive information as compared to PTA regarding hearing threshold in severely deaf developmentally retarded children.

DISCUSSION

It is known that the electrophysiological threshold depends on the electric potential record, which has close relation to the number of stimulated fibers, synchronism and size of electric activity. Thus, the subject may detect a piece of sound in weak intensity without necessarily registering corresponding electric potentials (Jerger, 1978). Therefore, it is essential to know the differences between the subjective and electrophysiological auditory thresholds, once its determination bears examiner's mind when conventional subjective exams do not present the expected results (Schochat, 2004; Gorga, 2002). BERA is usually prescribed in children below 5 years of age. After 5 years routinely PTA is done which is usually sufficient to decide the threshold of hearing. But in developmentally retarded children due to their cerebral or physical deformities, PTA testing does not provide the accurate information in children above 5 years. So the age group of 6 – 12 years was selected for the study. We have encountered very few studies in this matter as per all possible data searches. Maximum children were females in our study. In the study by Kumari *et al*. maximum subjects were male (Rakhi Kumari *et al.,* 2016). In this study most (60%) of the subjects were in the age group of 9 – 12 years. Study by Rakhi Kumari showed majority of cases (69.52%) were below 3 years of age (Gorga *et al.,* 2011) , and study by Thirunavukarasu had subjects in the age range of 1-5 years (Thirunavukarasu *et al.,* 2015). Mohammad Shamim Ansari *et al* investigated spastic CP children for ABR measures in the age range of 3 to 12 years (Mohammad Shamim Ansari, 2016**).**

Similarly, Mohammad Shamim Ansari and MA Hafiz Ansari studied hearing impairment in 110 children of 2-10 years of age of both genders with cerebral palsy, respectively (Mohammad Shamim Ansari, 2015) Majority of the subjects in our study (80%) were from low socioeconomic class. It is also reported in the literature that socioeconomic status has a role in the prevalence of hearing impairment. Niskar *et al*. (1998) described the prevalence of hearing loss among US children by socioeconomic characteristics. A total of 6166 children in the age range of 6 to 19 years completed hearing examination in a mobile Centre of the Third National Health and Nutrition Examination Survey conducted in span of six years from 1988. Children from families whose incomes at or below the US national poverty line were significantly more likely to have a hearing impairment when tested (Niskar *et al.,* 1998). Before a decade, Rao *et al*. (2002) estimated the prevalence of hearing impairment among children of school entry age, in rural regions of coastal South India. An otoscopic and audiometric evaluation was done for a total of 855 children studying in the first year of school. One of the important factors affecting the prevalence of HI was socioeconomic status. The prevalence of hearing impairment was significantly lower among children belonging to high socio-economic status (P<0.005) (Rao *et al.,* 2002).

In our study 70% of the subjects had cerebral palsy as an associated condition. Delayed cry, birth asphyxia, cerebral palsy, and neonatal seizures can cause brain hypoxia (12, 18) affecting central auditory pathways leading to hearing loss. Mohammad Shamim Ansari, MA Hafiz Ansari reported mild, moderate, and severe degree of hearing impairment in 52%, 26%, and 22% of the 110 children of 2-10 years of age of both genders with cerebral palsy, respectively (Mohammad Shamim Ansari, 2015). In 11 children (55%) there was good agreement between BERA and PTA results (Graph -1). In study by Rakhi Kumari, such finding was seen in 62 cases (59.05 %). Similarly the work by V. Rupa showed an agreement between these 2 tests in 54 cases (57.4%). In our study, 30 % of the cases showed no agreement between these 2 tests. Study by V. Rupa also showed no clear cut agreement between BERA and PTA, as in 22 cases diagnosis was possible only by BERA. In our study, in 15 % cases - estimation of hearing threshold could only be made by BERA , because in 5% cases it was inconclusive PTA finding and in the rest (10%) , there was no response by PTA.. Similar findings are also seen in the study by Rakhi Kumari (2016) and Rupa (1995).

In the study by Rakhi Kumari in 18 cases (17.14%) a diagnosis was possible only by the results of BERA , as 10 cases showed inconclusive PTA finding and in 8 cases there was no response to PTA. Also the result of study by V. Rupa showed a dilemma where the diagnosis could be made only by BERA due to considerable difference between PTA and BERA results in 7 cases. This study had inconsistent response by PTA in 5 cases and no elicitable PTA response in 6 cases.

Limitation

- The relationship between the measures is complex, however, as the procedures differ from one another distinctly. While BERA elicits an electrophysiological response from the auditory system to the level of the brainstem, the PTA elicits a perceptual response, which reflects the involvement of the entire auditory system. Furthermore, the stimuli have different acoustic properties, and so the estimation of behavioral thresholds from ABR thresholds must take multiple factors into account.
- These results cannot be generalized, since it depends on technical conditions which are particular to each laboratory.

Conclusion

This study concludes that BERA test should be performed only, in inconclusive PTA findings and BERA should be the test of choice in difficulty to perform PTA, as regards to developmentally retarded children.

Recommendation

All DR children in age group of 6- 12 yrs should be subjected to PTA test for determining the hearing threshold. Only in cases of non cooperation of patient, inconclusive or no response PTA finding, the BERA test should be advised. This shall add to the economy of the patient and decrease the unwanted workload on the electrophysiology laboratory.

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