Al-Azhar International Medical Journal

Volume 5 | Issue 5 Article 51

5-31-2024

Section: ENT

Clinical Value of Auditory Steady State Response Versus Tone Burst ABR for Evaluation of Severe to Profound Hearing Loss in Children

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How to Cite This Article

El-Zarea, Gehan Abd-Al-Rahman; Abbas, Ahmed Ismail; and Eldeeb, Ahmed Mohamed (2024) "Clinical Value of Auditory Steady State Response Versus Tone Burst ABR for Evaluation of Severe to Profound Hearing Loss in Children," *Al-Azhar International Medical Journal*: Vol. 5: Iss. 5, Article 51.
DOI: https://doi.org/10.58675/2682-339X.2453

ORIGINAL ARTICLE

Clinical Value of Auditory Steady State Response Versus Tone Burst ABR for Evaluation of Severe to Profound Hearing Loss in Children

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Abstract

Background: **Hearing makes it possible to identify and distinguish objects in the world based on the sounds they make, making sound-based communication feasible.**

Aim and objectives: **To identify the accurate threshold of hearing in young children with severe to profound hearing loss. It also aimed to support the choice of cochlear implant candidate or hearing aid fitting, as well as early treatment during the crucial phase for speech and language perception, to enhance the development and performance of each individual.**

Patients and methods: **Sixty participants participated in this case-control study, which took place at Al-Azhar University Hospitals' audio-vestibular unit and ENT department between December 2022 and November 2023. Two groups were formed: Group A: thirty children with 60 ears each that are hearing impaired. Group B: Thirty children (60 ears) with normal hearing.**

Results: **At all frequencies examined, the results demonstrated that the Auditory Steady State Response (ASSR) thresholds were substantially superior to the tone burst Auditory Brainstem Response (Tb-ABR) threshold.**

Conclusion: **Both Tb-ABR and ASSR may provide an accurate behavioral threshold prediction. ASSR can assess residual hearing in children with severe to profound hearing loss.**

Keywords: Auditory steady state response; Hearing loss; Tone burst ABR

1. Introduction

According to 2018 WHO estimates, children account for 7% (34 million) of all persons living with disabling HL in the world. While the most obvious effect of childhood hearing loss HL is on language development, it also has an impact on literacy, self-esteem, and social skills, which, in turn, can lead to reduced employment opportunities later in life and psychological consequences that can lead to feelings of isolation, loneliness, and depression. Childhood hearing impairment is a confirmed permanent bilateral hearing impairment ≥40 dBHL (hearing level) averaged over 0.5, 1, 2, and 4 kHz in the better-hearing ear. It can be attributed to environmental and genetic factors; therefore, it can be congenital or acquired.[1]

The importance of early identification and habilitation of hearing loss for improved access to auditory stimuli and for positive prognosis of speech and language is well established in the literature.[2]

An objective assessment of the function of the auditory pathway from the auditory nerve to the mesencephalon is provided by ABR, often referred to as brainstem auditory evoked potentials (BAEP). ABR may estimate the hearing sensitivity threshold and test synchronous neuronal function for those who cannot handle conventional behavioral audiometry.[3]

ABR is critical to diagnose hearing loss in newborns and young children who cannot undergo traditional behavioral auditory testing. Early diagnosis can establish prompt auditory rehabilitation such as hearing aids, cochlear implants, or hearing/speech therapy programs. Early intervention has been shown to promote improved speech and language development in children.[4]

So, the current study aims to evaluate the residual hearing in deaf children using Tb-ABR and ASSR to determine the optimal intervention method, either hearing aids or cochlear implantation.

Accepted 21 May 2024.
Available online 31 May 2024

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2. Patients and methods

Sixty participants participated in this case-control study, which took place at Al-Azhar University Hospitals' audio-vestibular unit and ENT department between December 2022 and November 2023. They were split into groups: Group A: Thirty deaf children (60 ears) and Group B: Thirty healthy individuals with normal hearing (60 ears). All children were tested by Auditory Steady-state Responses and tone-burst ABR recorded to eight stimuli simultaneously presented, four frequencies (500-1000-2000-4000 Hz) to each ear, evaluating the effectiveness of the inter-acoustic Eclipse 25 as an objective clinical test for identifying hearing thresholds in contrast to behaviorally subjective measurements.

2.1Administrative and Ethical Design: -

The Al-Azhar University Faculty of Medicine granted official clearance. The official authorization was acquired from the ENT Department's Audio-vestibular unit at Al-Azhar University Hospitals. Authorization from the Faculty of Medicine's Ethical Committee, Institutional Research Board (IRB) number 0000010. Every parent of a child enrolled in the study provided written consent.

2.2.Inclusion criteria: Young children with hearing impairments varied ages from one to five years.

2.3.Exclusion criteria: Chronic suppurative otitis media, otitis media with effusion, abnormalities of the external auditory canal, and auditory neuropathy spectrum disorder (ANSD).

2.4.Clinical assessment of these patients included:

History taking (obtained from parents): Name, age, and gender; complaints; the beginning, course, and length of the hearing loss; consanguineous union; also, similar situations in families with a have contributed to hearing loss.

Otological examination: to exclude any anomalies in the tympanic membrane or external ears.

Immittancemetry: Madison Zodiac type 1096 SA immittance meter being used

Combining auditory reflexes and tympanometry.

2.5.Hearing evaluation: -

Using the Two Channels Audiometer Pure Tone Interacoustics Ac40 model, we have a locally manufactured sound-treated room that complies with international sound-treated room standards.

Behavioral observation audiometry (BOA): For youngsters under three years old, we have included warble frequencies at 500, 1000, 2000, and 4000 Hz as part of sound-field audiometers at 45° azimuth. Behavioral and reflexive reactions were noted during the procedure, including those that were either reflexive (arousal, startle, or eye blinking) or attention-related (obtaining, identifying, listening, and expanding and decreasing movement). The test was run twice to ensure the results were accurate. For children with hearing impairments, audiometry of speech in the shape of verbal thresholds for detection (SDT) or spoken reception thresholds (SRT) was conducted as much as possible.

Play audiometry: To attain the threshold, pure tones with a frequency range of 1 K Hz, 2, 4, 8, and 0.5 K Hz should be used for air conduction tests on youngsters over three years old. Two test runs were conducted to guarantee accurate and consistent test findings.

2.6.Auditory Brainstem Response (ABR):

Using the Interacoustics Eclipse platform evoked a potential system.

Both spontaneous sleep and chloral hydrate (0.5cc/kg) sedation were used to assess the youngsters. This test was conducted with an evoked potential device based on the Interacoustics Eclipse 25 platform. In ABR, tone burst stimuli (0.5, 1, 2, and 4 KHz) were employed at a repetition rate of 21.1 p/s. The stimuli were transmitted by an insert phone. Each run involved 1000 sweeps, amplification 100,000 times, monitoring, and recording, and the answer was calculated as an average and processed across 30 and 1500 Hz within a 15 ms time range. Impedance levels of 3kΩ or less were advised. Lastly, the computer used electrodes to capture the auditory brainstem reaction to this sound.

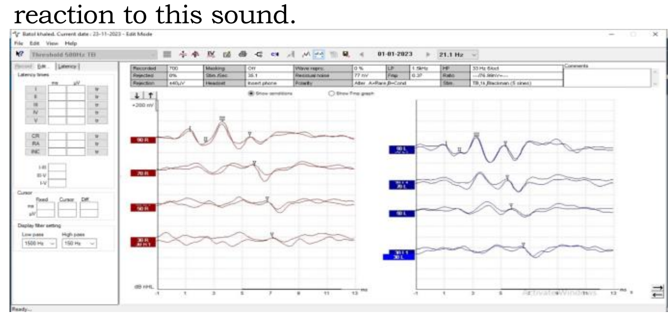


Figure 1. Screen of Tb-ABR testing and the resulting waves from one child from the control group

2.7.Auditory Steady State Response (ASSR):

Insert earphones were used to present testing stimuli with frequencies of 0.5, 1, 2, and 4 KHz utilizing the Interacoustics Eclipse platforms evoked potential system. In the frequency domain, ASSR examines amplitudes and phases. A mathematical detection system based on statistics was utilized to identify the presence or absence of responses. ASSR made Binaural testing possible; four frequencies may be heard simultaneously in each ear (eight simultaneous presentations). The electrode locations were cleansed and prepped to achieve a sufficiently low skin impedance. Insert earphones provided the test stimuli at four different frequencies: 74, 81, 88, and 95 Hz. In both ears, they were pure tones with modulation. Significant modulation was used to guarantee an adequate signal ratio and identify the presence of responses during sedation or natural sleep.

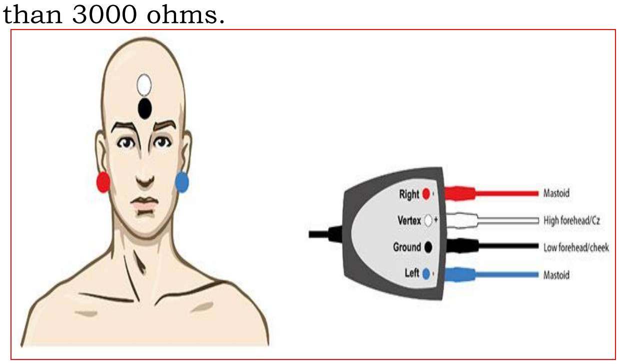
Every signal was introduced separately to each ear and possessed both amplitudes and frequency modulation. To enhance the response amplitude, 10% of the carrier tone's frequency modulation breadth and 100% of its amplitude modulation depth were employed. Initially, ASSRs were recorded at 100 dBHL, the highest sound level.

To establish an ASSR threshold, the stimulus level was lowered in steps of 10 dB until the response was no longer detectable. After that, it was raised in stages of 5 dB until the response was detected. When an ASSR was not obtained at the highest introduction level, the experiment was repeated.

Figure 2. screen of monitor of ASSR and the resulting estimated audiogram from one child from the control group

2.8.Electrode montage:

Both ABR and ASSR use the same electrode montage. Dual channel recording system consists of a ground on the forehead, a negative from the ipsilateral mastoid, and a positive from the Fpz. Inter-electrode impedance was less than 3000 ohms.



Rt: MASTOID Rt.; VERTEX: HIGH FOREHEAD CZ;GROUND: LOW FOREHEAD COMMON.;Lt: MASTOID Lt.

Figure 3. Electrode montage of Interacoustics Eclipse platform.

2.9.Statistical analysis:

Data were analyzed using Statistical Program for Social Science (SPSS) version 24. The qualitative data were expressed using percentages and frequencies. Quantitative data was expressed using the mean ±SD.

The amount of an individual set of digits divided by the total number of values is the mean, also known as the average. The standard deviation (SD) is a measure of the dispersion of a set of data. While a high standard deviation denotes that the data are dispersed over a larger range, a small amount of standard deviation (SD) suggests that the values are often close to the established mean.

distinct sample T test (T): applied when comparing groups. An analysis of variance, or one-way ANOVA, is employed for analyzing multiple groups collectively. For comparing non-parametric data sets, the chi-square test was used. The probability (P-value). P-values were classified as significant if they were less than 0.05, extremely significant if they were less than 0.001, and irrelevant if they were more than 0.05.

3. Results

This research was conducted on sixty children: thirty with severe to profound hearing loss and thirty healthy children with normal hearing. With a mean age of 3.02±1.22 years, the study group consisted of sixteen males (53.3%) and fourteen females (46.7%) in the age range of 1 to 5 years. Twelve women (40%) and eighteen men (60%) made up the control group, with a mean age of 2.7±1.1 years. There was no statistically significant distinction between the two groups. The study group had several risk factors for hearing loss; some of youngsters had several risk factors as indicated in Table 1 and Table 2.

Table 1. Comparison of demographic data between Study and control groups.

		STUDY (N=30)		CONTROL (N=30)		STAT. TEST	P-VALUE
AGE (YEARS)	Mean	3.02		2.7		T = 0.98	0.329 NS
	±SD	1.22		1.1			
GENDER	Male	16	53.3%	18	60%	X^2 = 0.27	0.602 NS
	Female	14	46.7%	12	40%		
FAMILY HISTORY OF HL	Negative	20	66.7%	28	93.3%	X^2 = 6.66	0.01 S
	Positive	10	33.3%	2	6.7%		

T: independent sample T test; S: p-value < 0.05 is considered non-significant; X2: Chi-square test; NS: p-value > 0.05 is considered non-significant.

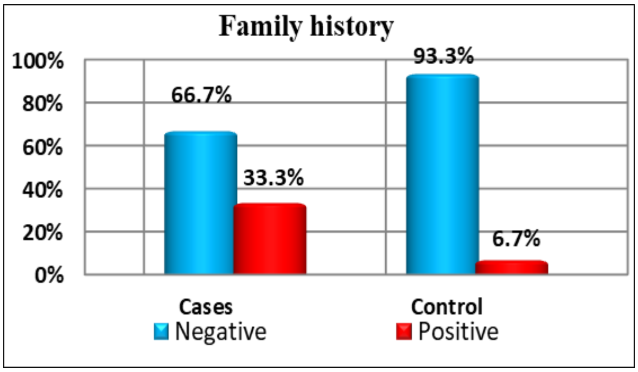


Figure 4. Comparison of family history between Study and control groups.

Table 2. Risk factors of the study group

	Cases No. (30)	*Percentage %*
Pre-natal event:		
Eclampsia	*1*	*3.3 %*
Peri-natal:		
Low birth weight	*1*	*3.3 %*
Preterm	*1*	*3.3 %*
Twins	*2*	*6.6 %*
Natal:		
Jaundice	*5*	*16.6 %*
Post-natal:		
Fever	*2*	*6.6 %*

Table 3. comparison between mean threshold of Tb-ABR and ASSR in the control group (60) ears.

CONTROL GROUP		TB-ABR (N = 60)	ASSR (N = 60)	TEST	P-VALUE
500 HZ	Mean	21.8	19.3	T = 3.35	0.001 S
	±SD	4.9	2.9		
1 KHZ	Mean	22.3	20.7	T = 2.26	0.025 S
	±SD	4.1	3.2		
2 KHZ	Mean	23.2	21.1	T = 3.2	0.002 S
	±SD	3.6	3.3		
4 KHZ	Mean	24.2	21.6	T = 3.9	< 0.001 HS
	±SD	3.9	3.5		

S: p-value < 0.05 is considered significant; HS: p-value < 0.001 is considered highly significant; NS: p-value > 0.05 is considered non-significant.

Both Tb-ABR and ASSR was obtained at the 4 frequencies regions of the 60 ears of the control group; there was a lower threshold for ASSR compared by Tb-ABR, as shown in the Table 3

Table 4. comparison between mean threshold of children with response of Tb-ABR and ASSR in Study group (60) ears.

STUDY GROUP		TB-ABR (N = 60)	ASSR (N = 60)	TEST	P-VALUE
500 HZ	Mean	90.8	89.2	T = 1.24	0.218 NS
	±SD	5.4	5.1		
1 KHZ	Mean	92.7	90.9	T = 1.07	0.285 NS
	±SD	6.07	6.3		
2 KHZ	Mean	93.4	91.5	T = 1.06	0.290 NS
	±SD	8.4	5.5		
4 KHZ	Mean	94.1	92.1	T = 0.97	0.332 NS
	±SD	7.7	8.06		

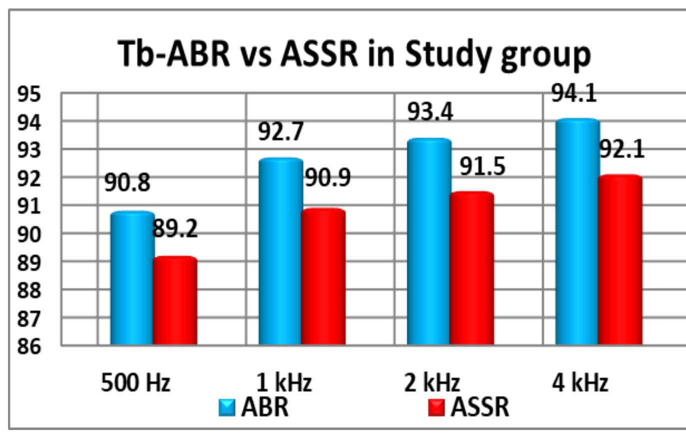


Figure 5. comparison between Tb-ABR and ASSR in Study group (60) ears.

In the Rt and Lt ears of the study group, Tb-ABR and ASSR were both obtained in low and high frequency areas; table 4 illustrates that ASSR had a lower threshold than Tb-ABR

Table 5. comparison between Tb-ABR, ASSR and Behavioral in the Study group (60) ears.

STUDY GROUP		TB-ABR (N = 60)		ASSR (N = 60)		BEHAVIORAL (N = 60)		TEST	P-VALUE
RESPONSE	Present response	33	55%	39	65%	32	53.3%	X^2 = 1.95	0.376 NS
	No response	27	45%	21	35%	28	46.7%		

X2: Chi-square test; T: independent sample T test; NS: p-value > 0.05 is considered non-significant.

4. Discussion

The majority of the 60 children in the study group exhibited indicators of risk for sensorineural hearing loss, with 30 having severe to profound hearing loss and the remaining 30 being healthy and having normal hearing. According to JCIH5, These risk factors are thought to contribute to hearing loss.

The percentage of the risk factors in the study group was 73.3% which included one child who had a Pre-natal event (her mother had eclampsia), four children who had Peri a natal event (1 of them had low birth weight, one preterm, and 2 with twins), five children had Natal events which were (pathological jaundice), two children had Post-natal event which was (non-specific fever) and 10 of them had a positive family history of hearing loss. (Table 1 & 2).

The Mean Tb-ABR thresholds in our study, which are 21.8 vs. 19.3 dBHL at 500 Hz, 22.3 vs. 20.7 dBHL at 1000 Hz, 23.2 vs. 21.1 dBHL at 2000 Hz, and 24.2 vs. 21.6 dBHL at 4000 Hz, were considerably higher than ASSR in the control group as shown in Table 3

The results of the current study agree with Rance G et al. The average disparity between the Tb-ABR and ASSR thresholds declined as the degree of hearing loss grew, and the mean dgroup'sce between the control group was consistently larger than the group's patient group. He demonstrated that the Tb-ABR thresholds were significantly higher than the ASSR thresholds. The mean difference between the Tb-ABR and ASSR thresholds declined as the degree of hearing loss grew. The mean difference between the control and patient groups was consistently large. He demonstrated that the Tb-ABR thresholds were significantly higher than the ASSR thresholds.[6]

Johnson TA & Brown CJ demonstrated that neither the predictive power of the ASSR procedures nor the preciseness with which either ABR technique predicted behavioral threshold differed. ABR thresholds were seen to be three dBHL closer to the behavioral threshold on average than ASSR thresholds.[7]

Gina L. Rotert showed that by comparing ASSR thresholds with ABR tone burst thresholds for corresponding frequencies; the correlation is significant at 500Hz and 2000Hz.[8]

Van Mannan A& Stapells D. found that multiple-ASSR and tone-ABR thresholds were strongly correlated, mainly in normal children.[9]

Regarding hearing deficits with a steep slope, the ASSR might be a more reliable indicator of behavioral thresholds Johnson T. & Brown C., 7. Moreover, because the highest presenting levels for these types of stimuli are only approximately 100 dB nHL or 105 dB nHL, tone burst ABR may not be able to distinguish between deep and severe hearing loss Stapells et al.[10]

This demonstrated that residual hearing, which may be assessed using the ASSR, is not excluded without ABR and behavioral thresholds. Similarly, a considerable percentage of ASSR identification that did not include ABR was recO'Rourke Stueve & O'Rourke..[11] study'she current study's examination of the ASSR data showed that while the high frequencies (2000 and 4000 Hz) displayed stronger threshold detection (91.5 & 92.1 dBHL), the lower frequencies (500, 1000 Hz) exhibited lower threshold detection (89.2 equipment's). The equipment's ability to offer the highest stimulation strength across frequencies may be one of the reasons for the variations in response detection across frequencies. At 1 kHz and 0.5 kHz, it peaks. The degree of loss of hearing in the group under study at this specific frequency may be related to the lack of response at 4 KHz in a significant number of children, Table 4

The outcomes of the present study are similar to Hassan et al. and Ahn et al., who, when studying individuals who had moderate to profound sensorineural loss of hearing, discovered that the highest percentage of missing ASSR occurred at 4 KHz. [12,13]

In research conducted by Swanepoel et al. The highest ASSR responses were seen at 2 KHz in 15 children with moderate to severe sensorineural hearing loss, followed by 1 KHz, 4 KHz, and 0.5 KHz.[14]

Table 5 indicates an additional element that led to the increasing discrepancies between the study's behavioral thresholds, Tb-ABR, and ASSR. This loudspeaker loudspeaker's 85 dB maximum sensitivity in the sound field facility which is well below the level of missing children Rodrigues et al. .[15]

In summary, click-ABR, with its broad spectrum content and quick onset, would not be the best option for frequency-specific ABR testing because of the present greater intensity ASSR threshold, which might not be feasiblTb-ABR'sse of the Tb-ABR's weak wave shape, the ASSR approach is especially well-suited for screening youngsters who have severe to profound hearing loss. When such ASSR results are achieved, it can give important information about whether the ear still has residual hearing that could help with reaction and how CI ought to be considered. When choosing and modifying assistive devices for young children and infants who cannot provide reliable behavioral thresholds, ASSR may be used. The unique and important additions that ASSR and Tb-ABR provide to the juvenile audiological test battery are substantial. There is a complementing relationship rather than a competitive one between the two strategies.

4. Conclusion

Both Tb-ABR and ASSR may provide an accurate behavioral threshold prediction. ASSR can assess residual hearing in children with severe to profound hearing loss.

Disclosure

The authors have no financial interest to declare in relation to the content of this article.

Authorship

All authors have a substantial contribution to the article

Funding

No Funds : Yes

Conflicts of interest

There are no conflicts of interest.

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