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Original Article

A STUDY ON AUDITORY STEADY STATE RESPONSE UTILITY TO EVALUATE SEVERE TO PROFOUND HEARING LOSS IN CHILDREN AND ITS IMPORTANCE IN MAPPING AND THERAPY

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ABSTRACT

INTRODUCTION: Cochlear implantation (CI) represents a significant advancement in audiology, offering profound benefits to individuals with severe to profound hearing loss. The assessment of residual hearing before CI is critical, as it can influence post implantation outcomes By using sustained sinusoidal or frequency-modulated tones, ASSR allows for precise frequency-specific testing with stimuli reaching intensities of up to 120 dB.
AIM: Auditory steady state response utility to evaluate severe to profound hearing loss in children and its importance in mapping and therapy
SAMPLE SIZE: 100
INCLUSION CRITERIA: • Children aged less than 5 years • both sexes (female and male) • Bilateral profound sensory-neural hearing loss with no response in BERA
EXCLUSION CRITERIA • Age below 6 months and above 5years
METHOD OF DATA COLLECTION: Review of data of children planned for cochlear implant surgery lacking ABR was done.
DISCUSSION: The findings provide insights into the clinical application of ASSR in this population. Speech outcomes were assessed using Categories of Auditory Performance (CAP) scores at 3 months and 1 year post implantation. The ASSR group exhibited slightly higher average CAP scores compared to the non-ASSR group, although this difference did not reach statistical significance. Individual variability in auditory processing and the short follow-up period may have influenced these findings.
CONCLUSION: In conclusion, ASSR is an indispensable tool for managing profound hearing loss in children. It enables early, accurate diagnosis, crucial for timely intervention that significantly impacts speech, language, and cognitive development.

Keywords*: C-Levels - Comfort Levels, T-Levels - Threshold Levels, Abr - Auditory Brainstem Responses ASSR - Auditory Steady State Response ,Cap Scores - Categorical Auditory Speech Perception Scores ,Nr - No Response ,Db - Decibels Khz – Kilohertz*

INTRODUCTION

Cochlear implantation (CI) represents a significant advancement in audiology, offering profound benefits to individuals with severe to profound hearing loss. Beyond restoring auditory function, CI plays a crucial role in cognitive and social development, particularly in children. Studies indicate that early implantation not only improves speech and language outcomes but also supports better integration into educational and social environments. The assessment of residual hearing before CI is critical, as it can influence post implantation outcomes. While behavioral audiometry remains the gold standard, its applicability in young children or those with developmental challenges can be limited. This has led to the exploration of objective methods like auditory brainstem response (ABR), which provides insights into auditory nerve function but lacks specificity in frequency discrimination and stimulus intensity beyond 90 dB. In contrast, the auditory steady state response (ASSR) offers a more refined approach. By using sustained sinusoidal or frequency-modulated tones, ASSR allows for precise frequency-specific testing with stimuli reaching intensities of up to 120 dB. This methodological advantage makes ASSR particularly valuable in cases where ABR results are inconclusive or when assessing residual hearing in individuals with severe to profound deafness. Moreover, ASSR has proven beneficial in evaluating patients with inner-ear malformations, where traditional hearing assessments may be challenging. This underscores its role in optimizing CI candidacy and predicting outcomes based on preoperative hearing status. 12 ASSR's ability to provide precise frequency-specific measurements and assess higher intensity stimuli up to 120 dB makes it invaluable in refining device settings and predicting speech perception abilities in CI recipients. This comparative analysis aims to explore how ASSR, in contrast to ABR, enhances our understanding of postoperative speech outcomes and contributes to personalised selection of candidates for implantation. 1

AIM

Auditory steady state response utility to evaluate severe to profound hearing loss in children and its importance in mapping and therapy

OBJECTIVES

To evaluate auditory steady state responses at high intensities in pediatric• cochlear implant candidates. To compare the post operative hearing outcomes using CAP scores.• To compare ASSR and BERA responses for residual hearing• Calculate post cochlear implant C-levels and T-levels•

REVIEW OF LITERATURE

Auditory steady state responses (ASSRs) are synchronized electrical potentials in the brain that match the frequency of periodic auditory stimuli. Research spanning decades has explored ASSRs comprehensively, revealing their clinical applications, neurophysiological mechanisms, and developmental insights. The objective of this study is to compare ASSR thresholds and behavioral test results at 500, 1000, 2000 and 4000 Hz in young children prior to cochlear implantation and compare the speech and mapping outcome with ABR test.

ASSR has advantages over ABR in certain clinical situations: 1. Frequency-Specific Information: o ASSR: Provides detailed frequency-specific information across a wide range of frequencies (typically 500 Hz to 4000 Hz). This makes it useful for generating an audiogram that can help in fitting hearing aids and other auditory devices. o ABR: Primarily provides information on high frequencies (2000-4000 Hz with clicks), though tone-burst ABR can be used for some frequency specificity. 2. Simultaneous Testing: o ASSR: Can test multiple frequencies simultaneously, reducing the overall test time. This is particularly beneficial when testing young children or other populations with limited attention spans. o ABR: Typically tests one frequency at a time, making the process longer and more cumbersome. 3. Objective Threshold Estimation: o ASSR: Provides objective threshold estimates that are closely correlated with behavioral audiometry thresholds, making it effective for assessing hearing in infants and individuals who cannot provide reliable behavioral responses. 39 o ABR: While ABR also provides threshold estimates, it may require more subjective interpretation of waveforms, particularly at lower stimulus intensities. 4. Automatic Response Detection: o ASSR: Employs automated analysis techniques, such as Fourier analysis, to detect responses, reducing the need for subjective interpretation and increasing consistency. o ABR: Requires trained clinicians to visually inspect and interpret waveforms, which can introduce variability and subjectivity. 5. Reduced Sedation Requirements: o ASSR: The ability to test multiple frequencies simultaneously can shorten the test duration, potentially reducing the need for sedation in young children or individuals who have difficulty staying still. o ABR: Longer test times for frequency-specific ABR may necessitate sedation in certain populations. 6. Clinical Efficiency: o ASSR: Its efficiency in testing multiple frequencies concurrently can make it more suitable for high-throughput clinical environments where time and resource management are critical. o ABR: Although ABR is highly valuable for neurological assessments, it may be less efficient for comprehensive frequency-specific audiometric assessments. 40

STUDY DESIGN:

Prospective study SAMPLE SIZE: 100

INCLUSION CRITERIA: • Children aged less than 5 years • both sexes (female and male) • Bilateral profound sensory-neural hearing loss with no response in BERA • No appreciable benefit with hearing aid • No medical or anatomical contraindications • Motivated parents for cochlear implant surgery & Willingness to comply with follow - up procedure.

EXCLUSION CRITERIA • Age below 6 months and above 5years

STUDY PLACE: The Department of Otorhinolaryngology and Head & Neck Surgery, Tertiary care centre, secunderabad.

METHOD OF DATA COLLECTION:Review of data of children planned for cochlear implant surgery lacking ABR was done. All ears were divided into two groups: with ASSR and without ASSR. T- levels and C-levels at postoperative 3-month and 1-year mappings were compared between the groups. To evaluate speech perception The Categories of Auditory Perception (CAP) scores were compared between the groups. Details regarding the proposed study were explained to the parents and informed and written consent was taken for inclusion in this study. Clearance was taken from ethics committee. 43 Data was collected in the proforma annexed here in. Tabulation of data was done and analysis was done.

STASTICAL ANALYSIS : The statistical software used for the analysis of the data and Microsoft word 2018 and excel 2018 have been used to digitalize the collected data and generate graph, pie chart and tables. The categorical values have been described as proportions and percentages. T test calculator for two independent mean was used. Significance was set at 0.05, two tailed hypothesis was selected to obtain t value and p values. p value

OBSERVATION AND RESULTS

Table 1:

Distribution according to age

Age group in month's	frequency	percentage
10-18	13	13%
19-27	18	18%
28-36	19	19%
37-45	20	20%
46-54	19	19%
55-63	11	11%

Table 2.

Distribution according to gender

Gender	frequency	percentage
Male	63	63%
Female	37	37%
Total	100	100%

Table 3:

c-levels at 3 months in implant mapping measured in current units.

	C- Levels in assr group	C-levels without assr group
mean	164.8	161.6
Standard deviation	12.08	13.8
Sample size	50	50
P value	0.229	

Table 4.

T-levels at 3 months in implant mapping measured in current units.

	T- Levels in assr group	T-levels without assr group
mean	102.06	121.92
Standard deviation	11.4	18.2
Sample size	50	50
P value	<0.05	

Table 5

C-levels at 12 months in implant mapping measured in current units.

	C- levels in assr group	C-levels without assr group
mean	162.4	182.77
Standard deviation	14.1	18.56
Sample size	50	50
P value	0.0571	

Table 6:

CAP SCORES at 3 months post implant

Cap scores in assr group	Cap scores without assr group

Mean	2.78	1.38
Standard deviation	0.62	0.59
Sample size	50	50
P value	0.69	

Table 7

	Cap scores in assr group	Cap scores without assr group
Mean	3.68	3.7
Standard deviation	0.67	0.53
Sample size	50	50
P value	0.104	

DISCUSSION:

This study investigated the utility of Auditory Steady-State Response (ASSR) in evaluating hearing and its impact on cochlear implant mapping and therapy outcomes in children with severe to profound hearing loss. The findings provide insights into the clinical application of ASSR in this population. Speech outcomes were assessed using Categories of Auditory Performance (CAP) scores at 3 months and 1 year post implantation. The ASSR group exhibited slightly higher average CAP scores compared to the non-ASSR group, although this difference did not reach statistical significance. Individual variability in auditory processing and the short follow-up period may have influenced these findings. Analysis of cochlear implant mapping parameters revealed significant results. The ASSR group demonstrated significantly lower average T levels compared to the non ASSR group, indicating more accurate determination of auditory thresholds. This outcome suggests that ASSR-guided threshold determination may lead to enhanced neural encoding of auditory signals crucial for speech understanding. The comparable C levels between groups suggest that ASSR did not significantly influence comfort levels during electrical stimulation, indicating consistent safety and tolerability of cochlear implantation irrespective of ASSR use. Young Kim et al. [1] retrospectively reviewed data from 16 child CI recipients lacking Auditory Brainstem Responses (ABRs). They found a positive correlation between residual hearing at 2 kHz ASSR and lower T-levels post-CI, underscoring the utility of ASSR in setting optimal CI parameters. Interestingly, they noted that children exhibiting ASSRs at all frequencies had higher CAP scores at 1-year post-surgery, suggesting a potential advantage in speech perception outcomes compared to those without ASSRs.. The findings of the present study were similar to those reported by Ramos et al. [3] in terms of significant correlations between behavioural and auditory steady-state 69 response (ASSR) thresholds across frequencies (500, 1000, 2000, and 4000 Hz). Both studies indicated that ASSR effectively detects residual hearing in cochlear implant candidates compared to traditional warble-tone audiometry. However, while Ramos et al. [3] noted strong correlations and comparable thresholds between ASSR and behavioral tests, they did not find significant differences in mean thresholds between the two methods at any frequency. These consistent findings across studies emphasize the reliability of ASSR as an objective tool for assessing residual hearing in cochlear implant candidates. The findings of the present study were similar to those reported by Casey and Small [4] in terms of comparing auditory steady state response (ASSR) thresholds with behavioural thresholds for air conduction (AC) and bone conduction (BC) in both infants and adults with normal hearing. Both studies underscored significant differences between ASSR and behavioral measures, particularly in BC thresholds, indicating a maturational air-bone gap (ABG) in infants that was more pronounced in ASSRs compared to visual reinforcement audiometry (VRA). However, unlike the present study which focused on cochlear implant candidates with hearing loss, Casey and Small [4] examined normal hearing populations, highlighting discrepancies in BC thresholds between ASSR and behavioral methods across age groups and suggesting the need for correction factors to enhance clinical implementation of ASSR in predicting BC thresholds. The findings of the present study were similar to those reported by Chiossi and Hyppolito [5] regarding the investigation of preoperative residual hearing in cochlear implant outcomes for children. Both studies underscored the beneficial impact of residual hearing on cochlear implantation outcomes, particularly in predicting 70 improved speech perception. However, while the present study focused on assessing residual hearing's direct correlation with electrophysiological thresholds and speech outcomes post-cochlear implantation, Chiossi and Hyppolito [5] conducted a systematic review across multiple studies evaluating auditory, language, and cognitive performances post-implantation. They emphasized the variability in defining residual hearing across studies and highlighted the need for more comprehensive research to establish clearer prognostic indicators for cochlear implant candidacy and outcomes based on preoperative residual hearing levels. The findings of the present study were similar to those reported by Lee et al. [6] regarding the clinical comparison of auditory steady-state response (ASSR) with click auditory brainstem response (C-ABR) in infants suspected of significant hearing loss. Both studies emphasized the effectiveness of ASSR in measuring hearing thresholds, particularly showing strong correlations with C-ABR thresholds across frequencies, particularly at 2-4 kHz. This indicates ASSR's utility as a reliable method for assessing hearing sensitivity in infants. Additionally, Lee et al. [6] highlighted that ASSR thresholds in infants with hearing loss were consistently higher compared to thresholds in adults with normal hearing, underscoring the practical application of ASSR in managing severe to profound hearing loss in infants. The findings of the present study were similar to those reported by Swanepoel and Ebrahim [7] concerning the comparison of auditory steady-state response (ASSR) with auditory brainstem response (ABR) thresholds in infants and young children with varying types and degrees of hearing loss. Both studies underscored the clinical utility of ASSR as an objective audiometric tool, particularly in cases where behavioral audiometry may not be feasible, such as in infants. Swanepoel and Ebrahim [7] found 71 that ASSR thresholds, especially at high frequencies (2-4 kHz), exhibited a strong correlation with click-evoked ABR thresholds across different categories of hearing loss.. Rodrigues et al.^[10] compared ASSR and ABR in diagnosing hearing loss in children, noting that ASSR allows for simultaneous testing across multiple frequencies. My study also supports the effectiveness of ASSR, particularly at 2 kHz, where a positive correlation with C and T levels was observed. However, unlike Rodrigues et al., my study found no significant difference in C levels but noted lower T levels in ASSR-tested ears, indicating ASSR's sensitivity in detecting subtle variations in hearing thresholds. Wang et al.^[11] compared ASSR and click 72 evoked ABR in infants, finding that ASSR could detect hearing loss across a broader frequency range. My study aligns with these findings, particularly at 2 kHz, reinforcing the versatility of ASSR in assessing hearing thresholds across different frequencies. Ramos et al.^[12] evaluated residual hearing in cochlear implant candidates using ASSR, demonstrating its accuracy in measuring residual hearing. My research further supports the use of ASSR in pre-implantation evaluations, particularly in identifying lower T levels, which could influence post-operative implant programming. Ogura et al.^[13] used otoacoustic emissions and MRI to diagnose cochlear nerve disease, highlighting the importance of comprehensive diagnostic approaches. While my study did not focus on cochlear nerve disease, the combined use of ASSR and ABR could potentially enhance diagnostic accuracy in complex cases

CONCLUSION

In conclusion, ASSR is an indispensable tool for managing profound hearing loss in children. It enables early, accurate diagnosis, crucial for timely intervention that significantly impacts speech, language, and cognitive development. The advantages of mapping using ASSR are significant; it ensures precise fitting of hearing aids and cochlear implants by providing objective, frequency-specific assessments. This precision enhances auditory perception and comfort, leading to improved auditory outcomes. Additionally, ASSR facilitates ongoing monitoring and adjustment of devices, ensuring that therapy remains effective and personalized. By optimizing the electrodynamic range—the range between the T (threshold) and C (comfort) levels—ASSR supports better speech understanding and environmental sound awareness. Lower T levels, which represent the softest sounds a user can detect, can contribute to improved battery life by requiring less power for sound detection. This balance between sensitivity and power efficiency is crucial for maximizing device performance and user comfort. By supporting accurate and adaptive audiological rehabilitation, ASSR helps children with profound hearing loss achieve their full potential in communication and learning.

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