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RESEARCH ARTICLE

Effects of restricting maximum possible intensity on auditory steady-state responses

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Abstract

Background and Aim: Auditory steady-state response (ASSR) has widespread usage in the clinical hearing assessment of infants and young children. The present study evaluated the effect of restricting maximum possible intensity to 100 dB HL on ASSR thresholds.

Methods: This retrospective study was conducted in multiple audiology centers. ASSR thresholds with restricted settings were evaluated in 58 infants (116 ears). They had absent otoacoustic emissions and click-evoked auditory brainstem response waveforms and bilateral severe to profound hearing loss in behavioral evaluations.

Results: ASSR thresholds were absent in 28%, 25%, 60%, and 70% of ears in 500, 1000, 2000, and 4000 Hz, respectively. The mean value of remained thresholds was approximately 90−95 dB HL.

Conclusion: Restricted ASSR settings are prevalent; however, they fail to provide extensive additional information about hearing sensitivity. Thus, manufacturers are suggested to improve ASSR setting and transducers and resolve the intensity restrictions. ASSR settings should be able to test auditory thresholds to level of 120 dB HL.

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Introduction

Auditory steady-state response (ASSR) is widely used for the hearing assessment of infants and young children. It could correctly estimate the hearing sensitivity of different frequencies in normal hearing and various types of hearing loss [1-3]. ASSR thresholds are frequently used in the evaluation and rehabilitation processes. It is measured in different patients, including hearing aid [4] and cochlear implant [5] users.

ASSR evaluations have many advantages; however, most of them are not exclusive. For example, ASSR provides a frequency-specific assessment, make it a better frequency-specific test than click-evoked auditory brainstem response (ABR) [6]. Tone burst-evoked ABR is also a proper frequency-specific evaluation; it could efficiently estimate hearing sensitivity in different frequencies [7]. The automatic algorithms of ASSR could simultaneously evaluate different frequencies in both ears. It makes the hearing evaluation faster and more objective. However, an expert clinician could also

Table 1. Absent auditory steady-state response thresholds (number and percent) in 500, 1000, 2000, and 4000 Hz

	Absent ASSR (n, %)			
Ear	**500 Hz**	**1000 Hz**	**2000 Hz**	**4000 Hz**
Right ear (n = 58)	18 (31.0%)	17 (29.3%)	35 (60.3%)	40 (69.0%)
Left ear (n = 58)	15 (25.9%)	12 (20.7%)	35 (60.3%)	42 (72.4%)
Both ears (n = 116)	33 (28.4%)	29 (25.0%)	70 (60.3%)	82 (70.6%)

ASSR: Auditory steady state response

correctly identify ABR waveforms in reasonable time sessions. Therefore, time-saving and complete automated evaluation is not a significant advantage for ASSR.

The ability to measure hearing sensitivity in severe to profound hearing loss is the main advantage of ASSR, compared to other objective hearing tests, like tone burst-evoked ABR. ASSR can evaluate hearing thresholds up to 120 dB HL, whereas maximum possible intensity in ABR is 90−100 dB nHL. However, ASSR is susceptible to an artifact in high-level intensity for air conduction [8] and bone conduction stimuli [8-10]. Testing at a very high-level intensity may require better detecting algorithms and transducers. Unfortunately, some settings restrict the maximum possible intensity to 100 dB HL. This condition may affect the main advantage of ASSR, compared to tone burst-evoked ABR, as a more available test. The present study evaluated the effect of restricting maximum possible intensity on ASSR thresholds in infants with severe to profound hearing loss.

Methods

This retrospective study was conducted in multiple audiology centers. The Ethics Committee of Mashhad University of Medical Sciences approved the study (Code No: IR.MUMS.REC 1398.030). A total of 58 patients (116 ears) were enrolled in this study. All of the data were collected from patients' audiological records. Initial auditory evaluations were performed at the age group of ≤ 3 months. These evaluations were mostly otoacoustic emissions (OAE), ABR, ASSR, and tympanometry. Furthermore, there were several follow-ups, including repeating previous tests and the behavioral evaluations of hearing sensitivity.

The inclusion criteria were as follows: bilateral severe to profound hearing loss in behavioral evaluations, good cooperation in behavioral evaluations, absence of OAE and click-evoked ABR waveforms in both ears because of the severity of hearing loss in the first evaluation and other follow-ups, normal middle ear function in the first session (excluding all of the cases with type B and C tympanogram), and no records of cochlear microphonic (CM) in usual ABR recording or any other sign indicating the possibility of auditory neuropathy or other neural disorders.

Results

ASSR evaluations were performed at the earliest possible time in the first few months after birth. The mean (SD) age of infants at the time of behavioral evaluations was 2.86 (1.45) years. In total, 15 (26%) infants were female. Table 1, presents the absence of ASSR thresholds in 500, 1000, 2000, and 4000 Hz.

Some of the infants had ASSR thresholds. Table 2 lists the mean (SD) scores of these thresholds. Number of remained cases are also presented in terms of each frequency.

Discussion

This study evaluated the effects of restricting maximum possible intensity on ASSR thresholds in infants with severe to profound hearing loss. The findings suggest that limiting

Table 2. Mean (standard deviation) of present auditory steady-state response thresholds in 500, 1000, 2000, and 4000 Hz

	Mean (SD) of threshold (dB HL)			
Ear	**500 Hz**	**1000 Hz**	**2000 Hz**	**4000 Hz**
Right ear	90.00 (10.80) (n = 40)	93.16 (6.51) (n = 41)	92.00 (8.64) (n = 23)	91.67 (11.12) (n = 18)
Left ear	90.73 (9.19) (n = 43)	94.32 (6.78) (n = 46)	95.00 (8.94) (n = 23)	92.86 (11.04) (n = 16)
Both ears	90.38 (9.92) (n = 83)	93.78 (6.64) (n = 87)	93.54 (8.82) (n = 46)	92.24 (10.90) (n = 34)

maximum possible intensity to 100 dB HL results in the inability of ASSR to evaluate hearing thresholds in the majority of cases with severe to profound hearing loss, especially in higher frequencies. Restricted ASSR fail to provide any additional information for these cases. These results are consistent with previous research [11]. In that study, 42 infants with the absence of ABR and OAE response were evaluated by ASSR test. The maximum intensity for different stimulus was 110 dB HL. Moreover, 27 (64%) infants had no response in the ASSR test. Additionally, 15 out of 27 infants had also no behavioral responses.

Although the obtained results in our study were expected, restricted settings are very common. Many audiology clinics are using restricted settings because of financial reasons, such as the better price of the instrument and after-sales services.

The hearing assessment in infants should be completed in the first few months after birth, according to the American Speech-Language-Hearing Association (ASHA) [12,13] and the Joint Committee on Infant Hearing (JCIH) [14] guidelines. Based on the 2007 JCIH position statement, infants must receive hearing screening, evaluation, and intervention before the age of 1, 3, and 6 months, respectively [14]. There are several behavioral tests for hearing evaluation of infants and children, including behavioral observation audiometry (BOA) and visual reinforcement audiometry (VRA). For performing VRA, the infant must be able to turn his or her head. The reliable VRA thresholds can be obtained from infants at the age of 5−6 months. For infants up to 4 months old, the observation methods like BOA are invalid and have high variability [12].

Behavioral assessments are critical in infants' hearing evaluations [12,13]. However, they are sometimes difficult to administer. They may require two trained audiologists, and the process may take several sessions. For these causes, some audiologists in developing countries wrongfully avoid behavioral evaluations. They mostly rely on objective hearing tests, like ABR and ASSR. They may use behavioral evaluations in older ages. The ABR test has some usage limitation in high-level intensity stimulus [1]. In the severe and profound hearing loss, click- and tone-burst ABR thresholds are absent. Thus, ASSR is the only remaining test that can evaluate the hearing thresholds of infants. However, restricting the maximum possible intensity also makes ASSR thresholds less helpful.

There is a secondary problem for using restricted ASSR settings. Based on JCIH guideline, infants with hearing loss must receive interventions (e.g. hearing aid prescription) before the age of 6 months [14]. In reality, many of our cases would receive hearing aids without having any valid and reliable behavioral or electrophysiological thresholds. In these conditions, the prescription of hearing aids and the subsequent rehabilitation are performed based on personal methods. These methods are not the best practices for infants and children with hearing loss.

One limitation of the present study was investigating the ASSR thresholds in infants with absent click-evoked ABRs. It mostly evaluates hearing sensitivity from 2000 to 4000 Hz. Many

of our cases didn't evaluate with tone burst evoked ABR. unfortunately, tone burst evoked ABR is less popular between the audiologists in our area and some clinicians (if they want to have a frequency specific evaluations), use ASSR evaluations with restricted settings. However, many of infants with absent click evoked ABRs may have tone burst evoked ABR thresholds especially in lower frequencies. Therefore, ASSR thresholds with restricted settings even may be less helpful relative to tone burst evoked ABR thresholds.

Conclusion

It seems that ASSR settings are not very successful in hearing evaluations of infants with severe to profound hearing loss. Restricting maximum possible intensity could hurt ASSR evaluations and cause many problems in hearing evaluations and interventions for infants with severe to profound hearing loss. The manufacturers are suggested to improve ASSR setting and transducers and resolve the intensity restrictions. ASSR settings should be able to test auditory thresholds to level of 120 dB HL.

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Conflicts of interests

There are no conflicts of interests to be declared.

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