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The Relationship between Hearing Thresholds Estimation and Results of Auditory-Verbal Therapy in Children with Bilateral Congenital Severe to Profound Sensorineural Hearing Loss

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ABSTRACT

Background: congenital severe to profound sensorineural hearing loss (SP-SNHL) causes serious difficulties in production and comprehension of speech, necessitates use of a thorough rehabilitation program at early age. The aim of this study was to evaluate the relationship between hearing thresholds and the result of auditory rehabilitation in children with bilateral congenital SP-SNHL.
Methods: This is a retrospective study. Thirty-five children (23 males and 12 females) with bilateral congenital SP-SNHL were evaluated based on Auditory Steady-State Response (ASSR). The mean age of children at the beginning of rehabilitation was 37.36±17.10 months. They received bilateral superpower hearing aids and auditory rehabilitation based on Auditory-Verbal Therapy (AVT) approach. Their Speech production and comprehension were assessed at the beginning and end of rehabilitation via Speech Intelligibility Rating (SIR) and Categories of Auditory Performance (CAP).
Results: The SIR and CAP scores showed improvement in 12 (34.3%) and 25 (71.4%) children, respectively. These children had lower ASSR thresholds in 0.5 to 4 k Hz relative to others. The mean ASSR thresholds were 85.63 to 97.50 versus 96.09 to 104.75 ($P<0.05$). Also, lower hearing thresholds were related to better results in auditory rehabilitation ($P<0.05$).
Conclusion: Lower hearing thresholds in children with SP-SNHL are associated with better rehabilitation results.

Introduction

Congenital severe to profound sensorineural hearing loss (SP-SNHL) causes serious difficulties in the progress of speech, hearing, and language abilities. Without proper intervention, these abilities remain at a minimal level. The conditions of these children necessitate use of a rehabilitation program at a very early age. This process involves a thorough rehabilitation including hearing aid prescription or cochlear implants [1]. Auditory rehabilitation is an effective and popular intervention for infants and children with SNHL. These children receive proper amplification (hearing aids or cochlear implants) as well as special training for improvement of hearing and speech abilities.

The hearing evaluation is a necessary step before the rehabilitation process. The Auditory Steady-State Response (ASSR) is a valid and reliable frequency specific test which is helpful in hearing evaluation of cases with SP-SNHL. ASSR is useful in hearing evaluation in very young infants when the behavioral results are not yet reliable. The ASSR results are comparable to auditory brainstem responses (ABR) [2, 3]. ASSR also offers a correct and reliable estimation of behavioral thresholds

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in cases with SP-SNHL [4]. The ASSR thresholds are useful especially in very young infants that we could not obtain a valid behavioral threshold. They are analogous to behavioral thresholds obtained several months later [5].

The effects of residual hearing have been investigated in many studies; generally, greater residual hearing is related to more success in auditory rehabilitation [6, 7]. However, this is not a simple and linear relationship and some studies have even showed adverse effects for residual hearing in both children [7] and adult population [8]. These studies reported less improvement in cases with residual hearing. A study evaluated the results of cochlear implantation on SP-SNHL children with absent ABR threshold. They used the ASSR thresholds for hearing evaluation and compared the results of cochlear implantation with Categories of Auditory Performance (CAP) [7]. They found that although residual hearing would improve some other aspects of cochlear implantation results, the children with a ASSR thresholds had poorer CAP scores in one year post-surgery [7].

Our theory about the result of auditory rehabilitation is related to residual hearing: if the children had more residual hearing, the results of auditory rehabilitation would be better, and this theory could be true in children with congenital SP-SNHL and even small differences of residual hearing. Maintaining the residual hearing is important, we must pay more attention to maintaining the residual hearing in children with bilateral congenital SP-SNHL. The purpose of this study is to evaluate the relationship between hearing thresholds as measured by ASSR and the results of AVT in children with congenital SP-SNHL.

Methods

Participants

This was a retrospective study. The subjects consisted of children with congenital SP-SNHL who were candidates for cochlear implantation and received auditory rehabilitation. The mean age of children at the beginning of rehabilitation was 37.36±17.10 months. None of them had any other disability except hearing loss. They had absent transient evoked otoacoustic emission (TEOAE) responses in both ears. Different instruments were used for evaluating TEOAE including Madsen (Denmark). The ABR (EP25, Intracoustic, Denmark) with click stimuli at maximum level was absent confirming the presence of SP-SNHL in both ears. They had normal tympanogram and no sign or symptoms of conductive hearing loss. The patients and their parents were informed consent for intervention and consent forms were taken. This study was approved by the ethics committee of Mashhad University of Medical Sciences (IR.MUMS.REC.1398.030, 04, 27, 2019).

Procedure

The subjects were previously evaluated via TEOAE and ABR test. They were also evaluated by ASSR before the AVT. The ASSR results were extracted from patients' files. This test was performed binaurally by EP25 (Intracoustic, Denmark) at 0.5 to 4 kHz in both ears via insert phone. Children were asleep during the test whereby 80Hz rate was used for evaluation. The mean 0.5 to 4 kHz thresholds greater than 80 dB HL in both ears were considered as indication for SP-SNHL. The ASSR is an objective test for hearing assessment. It is a valid and reliable test for evaluating the hearing thresholds.

Auditory rehabilitation involved fitting of bilateral superpower hearing aids, plus rehabilitation based on the Auditory-Verbal Therapy (AVT) approach. The AVT team consisted of audiologist, speech and language pathologist, and hearing trainer, whereby the consultation of psychologists and occupational therapists was also used. They received AVT for 4.80±4.09 months. Most children had Phonak hearing aids. The checking involved listening to hearing aid sound and checking the function of hearing aid with prescription software. The children received the rehabilitation from multiple centers and attended AVT sessions at least 3 days per week.

The results of auditory rehabilitation were assessed by the English version of Speech Intelligibility Rating (SIR) and CAP at the beginning and end of the rehabilitation period. The SIR is a tool for evaluating speech production in young children. It is easy, not very time-consuming, and reliable with a high inter-rater reliability [9, 10]. The SIR scales consist of 5 categories starting as "connected speech is unintelligible" as category 1. The highest category is related to most intelligibility of connected speech for all listeners. The CAP is a scale employed for describing the speech comprehension abilities of children [11]. It is easy to perform and suitable for evaluating speech comprehension in young children [12]. The lowest rating is 0 which is associated with no awareness toward sound and highest rating is 7 which is related to using telephone with a stranger listener.

Data Analysis

The analyses were performed in SPSS, version 19. The demographic data and ASSR thresholds were described by mean and standard deviations. The ASSR maximum intensity level in intra-acoustic instrument was 100 dB nHL, and as such the absent responses were recorded as 105 dB nHL. The hearing loss was symmetrical in most cases and we used both ears for analysis. The improvement of SIR and CAP score were evaluated between the beginning and end of the rehabilitation period. Any positive difference in this period was considered as improvement. The independent t-test was used for comparing ASSR thresholds between subjects with and without SIR or CAP improvement. The Fisher exact test was utilized for comparing the improvement of SIR and CAP scores among male and female subjects. The Pearson correlation coefficient was used for evaluating the relationship between the improvement of SIR and CAP scores and ASSR thresholds.

Results

A total of 35 children including 23 males and 12 females were evaluated in this study. The distribution of data was normal. The ASSR threshold was 92.50±9.734,

Table 1: Number and percent of children with different Speech Intelligibility Rating (SIR) and Categories of Auditory Performance (CAP) Scores for the beginning and end of the rehabilitation period

Speech Intelligibility Rating (SIR)			Categories of Auditory Performance (CAP)		
Rating	**Beginning**	**End**	**Rating**	**Beginning**	**End**
1	33 (94.3%)	23 (65.7%)	0	22 (62.9%)	8 (22.9%)
2	2 (5.7%)	7 (20.0%)	1	7 (20.0%)	12 (34.3%)
3	0	3 (8.6%)	2	2 (5.7%)	3 (8.6%)
4	0	1 (2.9%)	3	3 (8.6%)	0
5	0	1 (2.9%)	4	1 (2.9%)	4 (11.4%)
			5	0	6 (17.1%)
			6	0	2 (5.7%)
			7	0	0

Table 2: the comparison of ASSR thresholds between the subjects with and without Speech Intelligibility Rating (SIR) and Categories of Auditory Performance (CAP) improvement

	SIR improvement			CAP improvement		
	With (n=12)	**Without (n=23)**	**P value**	**With (n=25)**	**Without (n=10)**	**P value**
0.5 kHz	85.63± 11.732	96.09± 6.047	0.000	90.60± 10.480	97.25± 5.250	0.009
1 kHz	91.46± 8.905	96.30± 5.521	0.007	93.40± 7.656	97.75± 4.723	0.021
2 kHz	93.75± 12.959	100.76± 7.069	0.005	96.10± 10.987	104.00± 2.052	0.002
4 kHz	94.38± 11.162	102.28± 7.281	0.001	97.50± 10.558	104.75± 1.118	0.003

Speech Intelligibility Rating (SIR), Categories of Auditory Performance (CAP)

Table 3: the relationship among improvement of Speech Intelligibility Rating (SIR) and Categories of Auditory Performance (CAP) scores, and Auditory Steady-State Response (ASSR) thresholds

	SIR improvement		CAP improvement	
	r	**P value**	**r**	**P value**
0.5 kHz	-0.440**	0.000	-0.427**	0.000
1 kHz	-0.303*	0.011	-0.411**	0.000
2 kHz	-0.479**	0.000	-0.451**	0.000
4 kHz	-0.475**	0.000	-0.481**	0.000

*Significant at P<0.05, **Significant at P<0.01, Speech Intelligibility Rating (SIR), Categories of Auditory Performance (CAP)

94.64±7.189, 98.36±9.990, 99.57±9.508, for 0.5 to 4 kHz, respectively. Table 1 reports SIR and CAP scores for the beginning and end of the rehabilitation period. SIR and CAP improvement was observed in 12 (34.3%) and 25 (71.4%) subjects.

Table 2 compares the ASSR thresholds between the children with and without SIR and CAP improvement.

The comparison reveals that ASSR thresholds at various frequencies are different between the two groups. The improvement of SIR and CAP scores were not different among male and female subjects (0.57±0.992 versus 0.42±0.669 for SIR and 1.26±1.421 versus 1.92±1.379 for CAP, P>0.05). The relationship between improvement of SIR and CAP scores and ASSR thresholds has also been presented in Table 3.

These results show weak to moderate negative relationships between ASSR thresholds and improvements of SIR plus CAP scores. The improvement of SIR and CAP scores had also a significant relationship (r=0.636, P=0.000). This suggests that of hearing and speech ability improvements are interrelated.

Discussion

This study evaluated the relationship between residual hearing and outcomes of auditory rehabilitation. The results revealed that hearing thresholds were significantly different between children with different rehabilitation outcomes. There were relationships between hearing thresholds and improvements of SIR and CAP scores in children with congenital SP-SNHL. This relationship was not strong and as other studies showed, and it could relate to the effects of age at the beginning of the rehabilitation [13]. The AVT approach indicated successful results in the rehabilitation of children with SP-SNHL [14]. It also showed that AVT can improve different aspects such as speech and language development [14], voice parameters [15], and social skills [16] in children with hearing loss.

The effect of residual hearing has also been evaluated in other studies. The majority of these studies has been performed on children with cochlear implants. Earlier studies mentioned that the residual hearing may be related to different outcomes [17]. The more recent studies reported that the pre-cochlear implants residual hearing has a significant impact on the speech perception in children [6]. A study on children with cochlear nerve deficiency used ABR responses, and they compared the CAP scores after 2 years of using cochlear implants. They found that children with ABR thresholds had better improvements than children with absent ABR waveforms [18].

The relationship between residual hearing and rehabilitation outcomes may also be influenced by other factors such as age. In a study, the residual hearing in the cochlear implantation of adults' population had adverse effects on outcomes [8].

Our results showed a weak to moderate correlation between ASSR thresholds and rehabilitation outcomes. The results of rehabilitation using hearing aids and cochlear implants may relate to different factors. Previous studies suggested the effects of different factors such as

socio-economic status and residual hearing [19], but not gender [19].

This study was retrospective and it had several limitations. The ASSR maximum intensity in our study was 100 dB HL. This restriction may affect the correlation between ASSR thresholds and SIR plus CAP scores. Some instruments can stimulate up to 120 dB HL. Use of these instruments in future studies may be helpful. The second limitation was the lack of reliable behavioral hearing evaluation in our cases. Behavioral hearing evaluation could help reflect the relationship between residual hearing and result of auditory rehabilitation in children with congenital SP-SNHL.

Conclusion

Hearing thresholds are related to the result of auditory rehabilitation. Even a small difference in hearing thresholds could relate to improvement of SIR and CAP scores as well as better speech production and comprehension in children with SP-SNHL. Clinician should be observant about residual hearing and take the necessary cautions for preserving the hearing thresholds in hearing aid prescription.

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Conflict of Interests: None declared.

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