Auditory Steady State Response (ASSR) Frequency-Specific Thresholds with Absent Auditory Brainstem Response (click-ABR) Test Results among Filipino Children

Romeo L. Villarta Jr., MD, MPH[1]
Maria Luz M. San Agustin, RN, MClinAudio[2]

[1]*Department of Epidemiology and Biostatistics*
College of Public Health
University of the Philippines Manila
[2]*Ear Unit*
Philippine General Hospital
University of the Philippines Manila

ABSTRACT

Objective: Determine the frequency-specific thresholds of auditory steady state response (ASSR) of Filipino children with absent auditory brainstem response (click-ABR) results.

Methods: This is a cross-sectional study analyzing the frequency-specific thresholds of auditory steady state response (ASSR) of Filipino children with absent auditory brainstem response (click-ABR) results. The study population comprised of 99 pediatric patients referred for hearing assessment using electrophysiologic techniques at the Ear Unit of the Philippine General Hospital. The subjects underwent hearing threshold evaluation using both evoked-potential techniques (click ABR and ASSR) within a one-month period from January 2009 to March 2014. The ASSR results of patients with absent click-ABR were collected and analyzed.

Results: There were 99 patients who underwent both ABR and ASSR. Of the 65 patients with absent ABR thresholds results, 13 patients had unilateral absent ABR while 52 had bilateral absent ABR results. The data of hearing tests from the combined 117 ears with absent ABR hearing tests were collected.
The proportion of children with ASSR thresholds with absent ABR per frequency were:

- 500 Hz - 45/117 (38.5 %);
- 1000 Hz - 76/117 (64.0 %);
- 2000 Hz - 63/117 (53.8 %); and
- 4000 Hz - 41/117 (35.0 %).

The proportion of children with ASSR thresholds with absent ABR per number of frequencies were:

- 4 frequencies - 19/117 (16.2 %);
- 3 frequencies - 32/117 (27.4 %);
- 2 frequencies - 22/117 (18.8 %); and
- 1 frequency - 44/117 (37.6%)

Conclusion: In the absence of click- ABR response, ASSR may provide information about the levels of severe to profound hearing loss among children. The criteria of selection of candidates for intervention (hearing aids or cochlear implantation) should include results from hearing evaluation not only from behavioral and ABR thresholds but also from ASSR thresholds. This may ensure that exclusion of some children with severe and profound hearing loss who may benefit from the intervention will be minimized.

Keywords: *profound sensorineural deafness, evoked response audiometry, hearing thresholds*

With the implementation of universal newborn hearing screening in the world including the Philippines, more children will be identified at birth with hearing loss and subsequently evaluated for intervention. For young children, early diagnosis of hearing loss and early intervention with amplification or cochlear implantation allow access to sound and the potential to develop speech, language and listening skills needed for oral communication.[1,2] However, for a subset of hearing-impaired children with severe to profound hearing loss, current evaluation for

Correspondence: Dr. Romeo L. Villarta Jr.
Department of Epidemiology and Biostatistics
College of Public Health
University of the Philippines Manila
625 Pedro Gil St., Ermita, Manila 1000
Philippines
Phone: (632) 526 0784
Telefax.: (632) 525 4239
Email: rvillartajr@upm.edu.ph
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fitting of hearing aids or cochlear implants presents a special problem. Estimates of profound, early-onset deafness are around 4–11 per 10,000 children in the United States.[3] Current testing for children with severe to profound hearing using click-ABR (Auditory Brainstem Response) and behavioral test methods is limited by the inability to obtain frequency-specific thresholds.[4]

An absent auditory brainstem response does not allow meaningful conclusions about the amount of residual hearing. The estimation of residual hearing is relevant to the selection of a right habilitation strategy particularly in children with severe or profound hearing loss where the loss is overestimated by ABR.[5]

However, Auditory Steady-State Response (ASSR), an evoked potential test, can accurately measure auditory sensitivity beyond the limits of other test methods.[4] The ASSR system's primary advantage over the standard evoked potential test is the ability to differentiate between severe and profound hearing loss as well as distinguishing between levels of profound hearing losses, *e.g.* the difference between a 90dB and a 110dB hearing loss. This ability to differentiate is crucial in instances where a cochlear implant is being considered as well as accurately fitted amplification. Unlike ABR testing which does not differentiate the severe and profound levels, the ASSR evaluation in combination with the behavioral methods currently used will make earlier identification of hearing loss even more accurate and this is essential for the management of infants with severe to profound hearing loss.[6,7]

To the best of our knowledge, there are no published Philippine studies that quantify the ASSR frequency-specific thresholds of children with severe and profound hearing loss diagnosed with negative or absent response to click-ABR. This study would provide an estimate of the numbers of possible children with residual hearing who may be excluded from hearing intervention if the decision is based only on behavioral and ABR hearing thresholds.

The objective of this study was to determine the frequency-specific thresholds of auditory steady state response (ASSR) of Filipino children with absent auditory brainstem response (click-ABR) results.

METHODS

The cross-sectional study involved analysis of the frequency-specific thresholds of auditory steady state response (ASSR) of Filipino children with absent auditory brainstem response (click-ABR) results.

Sample Population:

Children referred for hearing assessment at the Ear Unit of the Philippine National Ear Institute and Philippine General Hospital because of the inability of conducted behavioral tests to provide reliable estimates of hearing sensitivity were included in the study. The children who participated in this study underwent hearing threshold evaluation using both evoked-potential techniques (click ABR and ASSR).

Data Collection:

Medical and audiologic records containing the ABR and ASSR results of children seen from January 2009 to March 2014 were reviewed. Only the records of children who underwent both ABR and ASSR testing within a 1-month interval period were included in the study. A written informed consent of the parents or legal guardian of each child was solicited. The University of the Philippines Manila Ethics Review Board approved the research protocol. All patients were tested using the standard Testing Protocol for ABR and ASSR of the Ear Unit of the Philippine General Hospital.[8] If deemed necessary using standard clinical procedure, the patient was sedated using chloral hydrate. Audiologic testing made use of the Biologic® Master® II Multiple Auditory Steady-State Evoked Response machine (Natus Medical Incorporated, San Carlos, CA, USA).

The first test performed was the click-ABR. The results were recorded using Biologic Navigator® evoked potential system. Surface electrodes were applied to the high forehead (active), the ipsilateral mastoid process (ground) and the contralateral mastoid process (reference). Electrode impedances never exceeded 3kohms. The click rarefaction polarity stimulus consisting of 100µs pulses of a maximum of 95dB nHL at a rate of 13.3/sec and a filter of 30 -1500Hz bandwidth with an amplifier gain of 10,000. Time window of 20msec were used to record the click-ABR. At each presentation level, a minimum of 1500 sweeps was averaged. A 10dB increment or decrement was used to determine the threshold. Threshold was defined by visual inspection of the waveform displayed on the computer screen.

ASSR testing immediately followed while the patient was still asleep or sedated. Patients were tested at 10dB above the previously determined ABR thresholds when available. Increments of 10dB and decrements of 10dB were used depending on the required number of sweeps per frequency and threshold. Patients tested for thresholds of 80dB HL and above were tested mono-aurally, one frequency at a time.

Data Analysis:

The results were codified as shown in *Tables 1 and 2*.

A retrospective review of the records of patients with absent ABR results was performed and the data inputted in an Excel® spreadsheet (Microsoft Corporation, USA) containing among others, the hospital record number, name, age, ABR thresholds and ASSR thresholds (for right and left ear). Descriptive statistical data analysis was performed using Stata 11® statistical software (StataCorp LP, Texas, USA).

RESULTS

There were 99 patients who underwent both ABR and ASSR within a 1-month period from January 2009 to March 2014. There were 47 males (52.5%) and 52 females (47.5%) with mean age of 3.6 years (SD=1.9 and range: 0.6 - 10).

Of the 99 patients, 65 patients had absent ABR thresholds results: 13 patients with unilaterally absent ABR results and 52 with bilaterally absent ABR results.

The data of hearing tests from the combined 117 ABR hearing tests were collected.

The proportion of children with ASSR frequency-specific thresholds with absent ABR per frequency is shown in *Table 3*. More than half of the patients with absent click-ABR had ASSR thresholds in the 1000 Hz (64%) and 2000 Hz (54%) levels. More than a third of patients had ASSR

Table 1. Coding manual for data entry for ABR Thresholds

Patient ID	Ear (left or right)	Data Entry for ABR Thresholds
		30 dB to 95 dB or absent response

Table 2. Coding manual for data entry for ASSR Thresholds

Patient ID	Ear (left or right)	ASSR THRESHOLDS (Frequency)	Data Entry
		500 Hz	*20 dB to 114 dB or* absent response
		1000 Hz	*20 dB to 120 dB or* absent response
		2000 Hz	*20 dB to 120 dB or* absent response
		4000 Hz	*20 dB to 120 dB or* absent response

Table 3. Proportion of children with ASSR Thresholds and absent click-ABR results:

ASSR THRESHOLDS (Frequency)	Proportion
500 Hz	45/117 (38.5 %)
1000 Hz	76/117 (64.0 %)
2000 Hz	63/117 (53.8 %)
4000 Hz	41/117 (35.0 %)

Table 4. Proportion of children with multiple ASSR Thresholds frequencies and absent click-ABR results:

Number of ASSR Thresholds frequencies	Proportion
4	19/117 (16.2 %)
3	32/117 (27.4 %)
2	22/117 (18.8 %)
1	44/117 (37.6 %)

thresholds in the 500 Hz (38%) and 5000 Hz (35%) levels.

The proportion of children with ASSR frequency-specific thresholds with absent ABR per number of frequencies is shown in *Table 4*. Less than half (44%) of the patients had ASSR thresholds in three or more frequencies. For those with other frequencies of ASSR thresholds, the results were still significant (1 frequency – 38%; 2 frequencies – 19%).

DISCUSSION

Relying on the evidence provided by click-ABR alone as basis for intervention planning for hearing loss such as prescription for hearing aid amplification and cochlear implantation would underestimate the number of children who may benefit from intervention. The results of the study show that around 35 – 64 % of children with absent ABR results have residual hearing shown in the ASSR thresholds in each tested frequency. Furthermore, around 16% exhibit ASSR thresholds in 4 frequencies. Clearly these numbers are significant. These findings confirm the conclusions of several studies that in children with no response ABR, additional electrophysiologic testing be conducted to acquire a more complete assessment of the child's hearing.[6,9]

The study results also support the contention of Swanepoel and Hugo that preliminary results indicate that absent ABR and behavioral thresholds do not preclude the possibility of residual hearing, making the ASSR a primary source of information regarding profound levels of hearing loss.[10]

Health personnel involved in planning intervention for children with severe to profound hearing loss should consider that evidence based on behavioral and ABR hearing thresholds alone may exclude children with possible residual hearing. The benefit of the ASSR is that the results may provide more frequency-specific threshold information for children who have severe to profound hearing losses. This information would provide more precise data to proceed with hearing aid fittings or determining cochlear implant candidacy. It should be noted however that the Joint Committee on Infant Hearing (JCIH) 2007 Position Statement does not recommend ASSR as the sole measure of auditory status in newborn and infant populations.[11]

Reliance on click-ABR alone for hearing evaluation may result in overestimation of the prevalence of hearing loss. Even in the absence of results of click- ABR thresholds, ASSR may provide information about the residual hearing of children with profound hearing loss. The criteria used in selection of candidates for intervention (hearing aids or cochlear implantation) should include results from hearing evaluation not only from behavioral and ABR thresholds but also from ASSR thresholds. This may minimize the exclusion of some children with profound hearing loss who may benefit from the intervention.

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