COMPARISON OF AUDITORY BRAINSTEM RESPONSE AND AUDITORY STEADY STATE RESPONSE PARAMETERS AFTER BIRTH, THREE MONTHS & SIX MONTHS HEALTHY INFANTS IN KERALA

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Abstract
Background: Threshold estimation of Auditory brainstem response (ABR) and Auditory steady state response (ASSR) changes from birth to three months to six months. If the audiologists and physicians should have a good diagnostic accuracy of threshold estimations, then they can provide a good health care for the patient.
Objective: Objective of the study was to measure ASSR & ABR threshold and Vth wave latency of ABR in infants immediately after their birth, after three months and six months. Another objective was to compare the ABR and ASSR parameters after birth, three months and six months.
Methodology: The study was done as a pilot study to find out threshold estimation prior to screen hearing loss in neonates. Study design was longitudinal study with follow ups. 30 healthy infants who fulfilled inclusion and exclusion criteria were included in the study. Parameters of ABR and ASSR were recorded after birth, three months and sixth month and were compared.
Results: Of the 30 infants were evaluated, 17 subjects were males and 13 subjects were females (43.33%). The mean latency of fifth wave was 7.35 after birth, 6.95 at 3 months and 6.53 at 6 months. In the ABR threshold estimation at birth were responded with mean value of 33.58, after 3 month responded with 31.67 and further responded with 29.00 after 6 months. The mean ASSR threshold at 0.5 KHz, 1 KHz, 2KHZ & 4 KHz was 24.72 after birth, 22.80 at three months and 21.65 at 6 months. All these parameters after birth, at third month and sixth month were statistically significant($p<.0001$).
Conclusion: All the parameters were reduced from birth to 6th month. So the age of infant must take into consideration while screening hearing loss. Even the threshold of ASSR and ABR varies with frequency, variations with different populations and even also with machine. So while screening hearing loss, all of these factors must be taken into consideration.
Index Terms – Auditory Brainstem Response, Auditory Steady State Response, Screening of hearing loss

INTRODUCTION

Children with severe to profound deafness can affect social, emotional, intellectual and linguistic development [1]. So an early screening and early intervention has shown to develop better speech and language skills than the children who receive delayed intervention [2, 3,4,5,6]. Hence universal screening is well established in developed countries [7, 8]. In India many of the hospitals, neither universal screening nor high risk screening are accurately done. Since high risk screening misses the other babies with hearing loss, a universal screening is better option [9]. The incidence of hearing loss in India is 1-6% [10].

Diagnostic methods of hearing loss such as puretone audiometry can be done only in adults but not done in infants below 6 months of age as these tests are not reliable and accurate. [11] Otoacoustic emission tests (OAE),[11] Auditory brainstem response (ABR) [6] and Auditory steady state response (ASSR) [6] are commonly used in screening neonates. OAE takes response upto cochlear level; ABR takes upto brainstem level where as ASSR takes upto cortical level. In most of the hospitals, OAE is performed by attenders or nurses. So the test may not be accurate. ABR & ASSR requires an audiologist to perform. In OAE test it may give false positive result in the presence of debris in external auditory canal of new born babies. [11] Two types of ABR are used in the literature; Tone PIP and

Click ABR with each have advantages and disadvantages. Tone PIP ABR is more frequency specific whereas in click ABR the fifth wave morphology is much better. [12]

Click-auditory brainstem response (CABR) test paradigm applies acoustic click stimuli, and these may generate synchronous neural firing in the auditory pathway and this correlates with the best or average threshold in the 1-4 kHz range. [13] Yet detailed information concerning the frequency-specific thresholds cannot be obtained, and the hearing loss that's restricted to particular frequencies may be overlooked. The auditory steady state response (ASSR) is an alternative evoked potential technique that uses periodic electrical responses of the brain to auditory stimuli that are presented at a fast enough rates for eliciting successive responses. These tones are reasonably frequency-specific because the continuous tonal stimuli contain energy in a much smaller frequency range than do clicks. [14, 15]

ASSR has more frequency specificity as compared to ABR. ASSR can screen the degree of hearing loss in each frequency. So hearing aid fitting can be such as digital hearing aids have to be programmed based on hearing loss in each frequency. ABR test is limited by two factors. A subjective visual inspection method was used to determine the threshold. This makes it difficult to differentiate between severe and profound hearing loss. They are also limited by the restrictions on maximum presentation levels. ASSR has the ability to obtain the highest output levels that exceeds the range of recordable hearing thresholds. It also has an automatic response detection system that eliminates the need for subjective evaluation of the responses. [16, 17, 18]

The threshold of ABR and ASSR at different month was not estimated and Vth wave latency of ABR at different months is not evaluated yet in Indian population. However, it is not known, whether threshold estimated changes from birth to three months to six months. This was a pilot study to find out the estimation of threshold to screen hearing loss with ABR and ASSR in an Indian population. If the audiologists and physicians should have a good diagnostic accuracy of threshold estimations, then they can provide a good health care for the patient. So the aim of the present study was to measure ASSR & ABR threshold and Vth wave latency of ABR in infants immediately after their birth, after three months and six months. Another aim was to compare the ABR and ASSR parameters after birth, three months and six months.

METHODOLOGY

This study was conducted in the Department of Audiology and Speech Pathology, Sankar Institute of Medical Science and Research Center. Study design was longitudinal study. Initial assessment was done immediate after birth within 24 hours; follow up was done at 3rd month and 6th month. Study sample were taken through a convenient sampling method from the neonatology department at Sankar Institute of Medical Science and Research Center, Kollam, Kerala, India. 30 infants with normal hearing of either gender were included in the study and both ears were evaluated for parameters. The researcher explained the study procedures to the infant's parents and their signed consent was taken. Neonates then had undergone a regular otoscopic examination and tympanometry to done to find out visual presence of a debris, ear wax, meconium and presence of foreign body. The babies with middle ear pathologies, auditory neuropathy, presence of a systemic disease, intrauterine problems, craniofacial anomalies, and trauma; and preterm infants were excluded from the study. Then the subjects underwent auditory brainstem response testing, [19] followed by Auditory steady state response testing. [19] This order was reversed for another set of subjects. The sequence of order of testing for the subject based on block randomization.

The ABR evaluation was carried out using GSI Audera equipment with ER 3A insert earphones. The testing was carried out in an electromagnetically shielded quiet room. Earthing was done properly to avoid the electrical interferences, which may affect the test results. The recording of ABR was done with placement of inverting electrode on the mastoid of the test ear, noninverting electrode on the vertex and ground electrode on the forehead. Before recording, the electrode sites were thoroughly cleaned using surgical spirit and abrasive paste. Conductive electrode gel was applied on the electrodes and mounted in respective places. Recording of ABR waveforms was done for rarefaction stimulus polarity.

Time window was kept up to 12 ms and the rate of stimulus presentation was 11.1 per second. Number of cycles used in this study was 1200. Stimulus used in this study is click having the range 2000 to 4000Hz. Clicks provide high frequency (2000 Hz to 4000 Hz) information. The recording was done twice and the best wave morphology is noted. A 5 dB increment or decrement was used to determine the threshold. Threshold was defined as the lowest level at which a C-ABR was present, as determined by visual inspection of the waveforms displayed on the computer screen. The lowest ABR threshold estimation and latency of fifth wave is documented.

ASSR testing was carried out in an electromagnetically shielded quiet room. Earthing was done properly to avoid the electrical interferences, which may affect the test results. The ASSR recording was done with placement of inverting electrode on the mastoid of the test ear, noninverting electrode on the vertex and ground electrode on the forehead. Before recording, the electrode sites were thoroughly cleaned using surgical spirit and abrasive paste. Conductive electrode gel was applied on the electrodes and mounted in respective places. ASSR can be done in four ways amplitude modulation, frequency modulation, exponential modulation and mixed modulation. In the present study mixed modulation was used. The testing parameters used for ASSR in this study are Amplitude Modulation depth of 100% and Frequency Modulation depth of 20%. Carrier frequencies selected in this study are 500Hz, 1000Hz & 2000Hz and 4000Hz. TDH 39 supra aural headphones used to present acoustic stimulus to the subject's ear. Modulation rate can be 80 Hz or 40 Hz. In the present study 80 Hz was used as 40 Hz babies need to be awake. Acoustic stimuli presented to the subject's ear and the electrodes collected the electrophysiological activities and displayed it in the computer display. ASSR threshold estimation was documented for 500Hz, 1000Hz & 2000Hz and 4000Hz. Both ASSR and ABR parameters were estimated again after third month and six months.

The variables taken for the study was subjects V^{th} wave ABR, threshold estimation of ABR and threshold estimation of ASSR at 500Hz, 1 kHz, 2 kHz, 4 kHz, were recorded and analyzed for the study at three stages. The data was compared between the values after birth, third month and sixth month. Data analysis was performed by SPSS (version 17) for windows. Alpha value was set as 0.05. Descriptive statistics was performed to find out mean and standard deviation for outcome variables. One way ANOVA was used to compare the threshold estimation of ASSR, ABR and fifth wave latency of ABR after birth, three month and six months. A post hoc analysis with Tukey's test was used to analysis if comparison between groups was significant. Microsoft excel table were used to general table and graph etc.

RESULTS & DISCUSSION

Results

Of the 30 infants were evaluated, 17 subjects were males (56.67%) and 13 subjects were females (43.33%). So a total of sixty ears of infants were analyzed for parameters. In the present study the mean latency of fifth wave was 7.35 with standard deviation of 0.26 at birth was reduced to 6.95 at 3 months with standard deviation 0.24 and it was further reduced to 6.53 with standard deviation of 0.25 at 6 months. In the ABR threshold estimation at birth were responded with mean value of 33.58, after 3 months they were responded with 31.67 and further they were responded with 29.00 after 6 months (Table I & Figure 1& II). A post hoc analysis revealed that comparison of parameters between different stages were significant ($p < .0001$)

Table I: comparison of ABR parameters third months and six month

Sl.No	Parameters	Birth	Third Month	Sixth month	þ-value
1	ABR 5^{th} wave latency	7.35±0.26	6.95±0.24	6.53±0.25	0.0001
2	ABR Threshold	33.58±2.27	31.67±2.38	29.00±2.02	0.0001

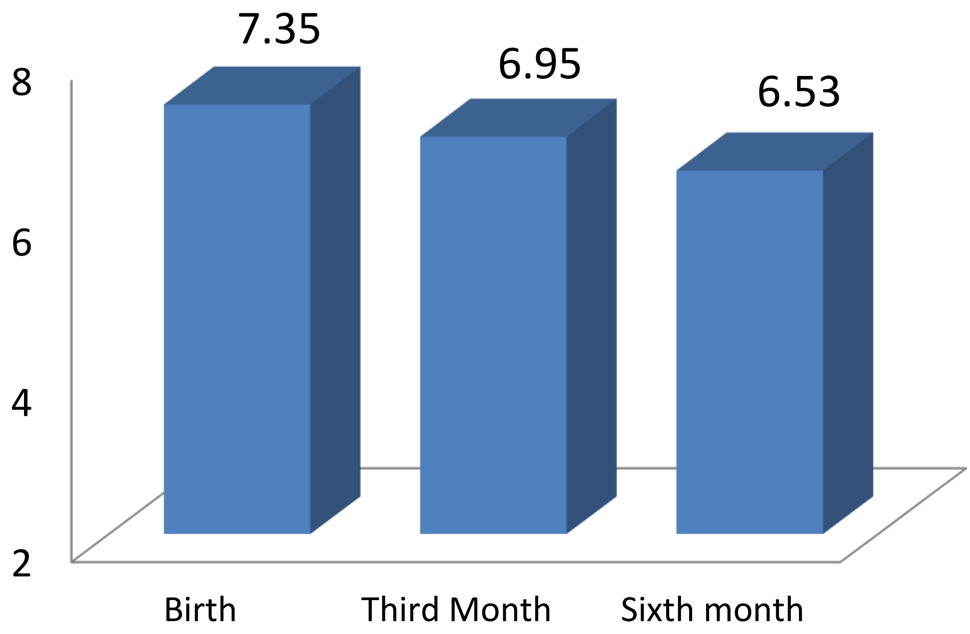

Figure I: ABR V^{th} wave latency

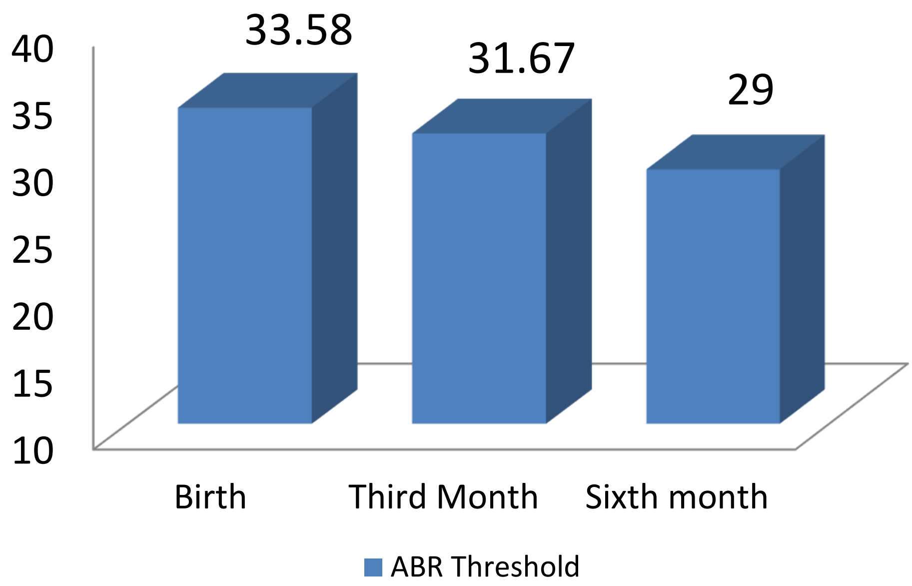

Figure II: ABR Threshold

In the study the mean ASSR threshold for 500Hz were 28.73 at birth, 27.26 at 3rd month and 26.08 at 6th month. In the study the mean ASSR threshold for 1000Hz were 25.07 at birth, 22.91 at 3rd month and 21.01 at 6th month. In the study the mean ASSR threshold for 2000Hz were 21.66 at birth, 19.92 at 3rd month and 18.81 at 6th month. In the study the mean ASSR threshold for 4000Hz were 23.43 at birth, 21.15 at 3rd month and 20.72 at 6th month. The overall mean ASSR value for 500Hz was 27.36, the overall mean ASSR value for 1000Hz was 22.99, the overall mean ASSR value for 2000Hz was 20.13, and the overall mean ASSR value for 4000Hz was 21.77 (Table II & figure 3). A post hoc analysis revealed that comparison between third month and sixth month were significant (p value <.001) at 500 Hz, and 2000 Hz whereas for 1000 comparison was significant at <.0001. At 4000Hz it was not significant (p value >.396) between second stage (three months) and third stage (six months). Average ASSR Threshold from .5KHz to 4KHz after birth to 6 months is illustrated in table III and figure IV which was statistically significant (P value <0.0001)

Table II: Comparison of ASSR threshold estimation at birth, third month, and sixth month

Sl.No	Threshold estimation	Birth	Third Month	Sixth month	þ-value
1	At 500Hz	28.73±1.67	27.26±2.19	26.08±1.38	0.0001
2	At 1000Hz	25.07±1.38	22.91±1.29	21.01±2.33	0.0001
3	At 2000Hz	21.66±1.59	19.92±1.56	18.81±1.90	0.0001
4	At 4000Hz	23.43±1.22	21.15±1.99	20.72±2.13	0.0001

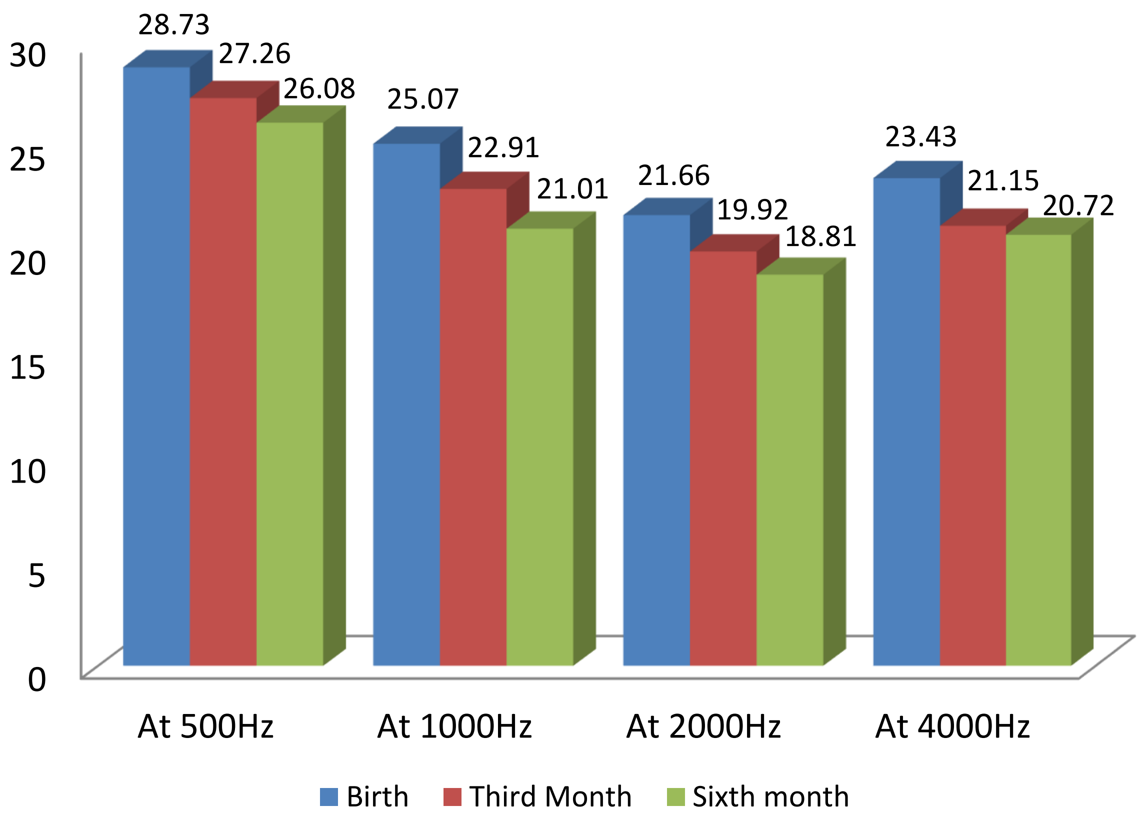

Figure III: Mean ASSR Threshold at 500Hz,1000Hz,2000Hz and 4000Hz

Table III: Mean ASSR Threshold from (.5KHz to 4KHz after birth, 3months & 6 months)

Sl.No	Parameters	After Birth	After Third Month	After Sixth month	þ-value
1	ASSR	24.72	22.80	21.65	0.0001

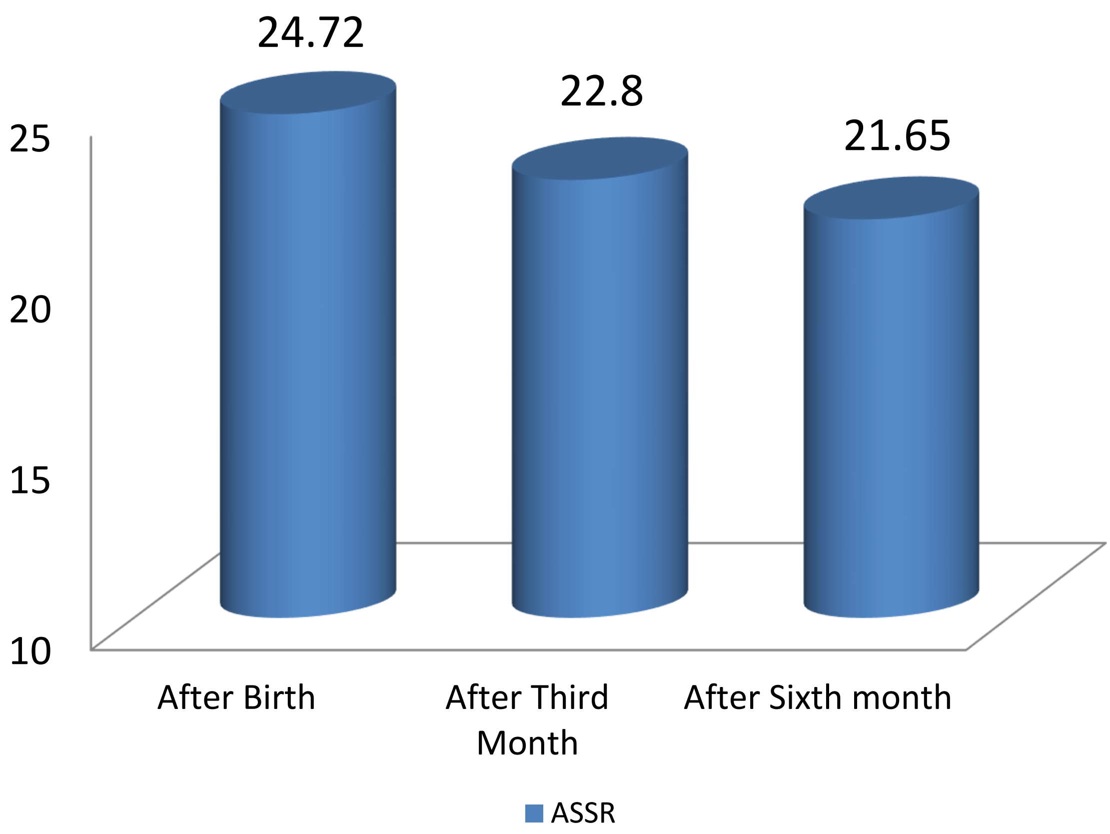

Figure IV: Mean ASSR after birth, after third month and after sixth month

Discussion

The aim of the study was to estimate ASSR & ABR threshold and Vth wave latency of ABR in infants immediately after their birth, after three months and six months and also was to compare the ABR and ASSR parameters after birth, three months and six months. Although studies have done previously to estimate threshold, they were not estimated at particular intervals i.e after birth, third month and sixth month. And also a normative data was not available for Indian population. It is also necessary to find out whether these threshold values remain same even if the study population changes.

The effects of hearing loss on ABR latencies have been well established in adults. But they are less used in neonatal diagnostic hearing assessment. Vander Werff et al (2009) [6] reported that wave V latency functions for Air conduction and Bone Conduction Tone based ABR (BC-TBABR) also differed between infants and adults as a function of frequency. Infant BC-TBABR latencies were well matched between those with normal hearing and conductive Hearing loss, whereas Air Conduction TBABR latency functions separated these groups. Study also concluded that difference in Vth wave latencies evoked by click ABR at 80 dB nHL were indicative of normal hearing or conductive hearing loss. Margaret Baldwin and Peter Watkin [20] examined the ability of click auditory brain system response (ABR) undertaken below the age of (from expected date of delivery) to differentiate between conductive and sensorineural hearing loss (SNHL) using the latency of wave V measured 20 dB above threshold. The mean latency of Vth wave 20 dB above threshold was1 mille seconds shorter in those with SHNL compared with those with TCHL. There were significant differences between children with PCHL and SNHL but no difference between those with PCHL and TCHL. In the present study, mean latency of fifth wave at birth was 7.35 was reduced to 6.95 at 3 months and it was further reduced to 6.53. In the ABR threshold estimation at birth were responded with mean value of 33.58, after 3 months they were responded with 31.67 and further they were responded with 29.00 after 6 months. The observed improvement of hearing thresholds and latency over the months has been mainly attributed to neuro- maturation and increased myelination of the auditory pathway. For infants showing an auditory neuropathy profile have a much greater probability of ABR recovery.

The mean ASSR thresholds of the infants in this study were 27.36 dB HL at 500 Hz, 22.99 dB HL at 1 K Hz, 20.13 dB HL at 2 KHz and 21.77 dB HL at 4 KHz. This was in accordance with study done by Hyo Sook Lee et al [21] where mean ASSR threshold was ranged from 23 to 33 dB HL in infants. Also in their study, author compared the infants' values with adults whose threshold ranged from 16 to 21 dB HL. The author concluded that infants' threshold values were about 10 dB HL higher than those of the normal hearing adults. They have taken the infants upto one year but in the present study infants upto six months was taken. In another study done by Lins O G et al, [22] the mean ASSR thresholds in infants 1-10 months old were reported to be about 20-30 dB HL. The present study threshold ranged between 20 to 28 dB HL. A higher threshold can be seen in subjects with hearing loss. But in the previous studies and present study infants with normal hearing was taken. Still our study threshold was 5 dB HL was lesser than previous studies. This can be explained by factors such as machine variation. Even study population was different among the studies.

Another important finding is that ASSR threshold is higher at low frequency and is lower at high frequency. This finding was same across for all threshold estimated after birth, third month and sixth month. This was in accordance with studies done by Richards F W et al [23] and Hyo sook et al [21] where the change was around 10 dB HL from 500 Hz to 4000 Hz. However, in the present study, this change was around 5 dB HL from 500 Hz to 4000 Hz. One of the reason for higher threshold for lower frequencies explained in literature was that the higher threshold at low frequency than that at high frequency is that high frequency stimuli elicit relatively larger ASSR amplitudes in sedated subjects [24], which may lead to desynchronization of the neurons generating the responses because of jitter in the transmission time between the cochlear receptors and the neural generators. [22] Even an electrical disturbance, background noise, artifact, misplacement of earphones may account for this difference in higher threshold at lower frequencies. The average ASSR threshold 0.5-4 KHz after birth was 24.72, after three months was 22.80 and after six months was 21.65. As the baby grows there is more neuro-maturation, more myelination of the nerves and receiving signal will be faster. This accounts for the lowering the ASSR threshold values from birth to six months. One of the limitations of the study was that, parameters were not analyzed after one year of birth and was not compared with values obtained after birth, three months and six months. Infants with congenital or progressive hearing loss were not taken into consideration in the present study. Further study can be done to compare the parameters ABR and ASSR of infants with adults in Indian population. Study can also be done to find out the relationship of threshold of ABR with ASSR in infants with hearing loss in Indian population.

CONCLUSION

The objective of the study was to measure ASSR & ABR threshold and Vth wave latency of ABR in infants immediately after their birth, after three months and six months and to compare the ABR and ASSR parameters after birth, three months and six months. All the parameters were reduced from birth to 6th month. So the age of infant must take into consideration while screening hearing loss. Even the threshold of ASSR and ABBR varies with frequency, variations with different populations and even also with machine. So while screening hearing loss, all of these factors must be taken into consideration.

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