Development of Tone Burst ABR in Infants

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Abstract

Frequency-specific ABR is universally recommended to determine the thresholds in infants who do not pass new-born hearing screening. However important variable in the interpretation of ABR tracings, especially in premature infants, is the effect of maturation on the waveforms. The present study was carried out with the aim of studying the effect of age on tone burst evoked ABR in infants and to see the maturational changes of tone burst evoked ABR in infants. Infants were divided into two groups; group I with age range of 0 to 6 months (15 ears) and group II with age range of 6 to 12 months (15 ears). Wave V latency changes of 500 Hz and 4000 Hz at intensity levels of 70 dB nHL, 50 dB nHL, 40 dB nHL and 30 dB nHL were analysed in both the groups. There was significant correlations for wave V latency across age groups for 500 Hz at all the intensities, and for 4000 Hz correlation was present only for 70 dB nHL and 50 dB nHL. Significant difference in latency was observed within age groups across 2 frequencies at different intensity levels. Use of tone burst ABR is helpful in finding the frequency specific threshold in infants. Also by seeing the latency change, maturation of the auditory system can be easily understood. ***Keywords:*** *Latency, ABR, Maturation Change, Tone burst, Latency.*

Introduction

Auditory brainstem response (ABR) is an electrical potential and it is a complex response to particular types of external stimuli which represents neural activity generated at several anatomical sites. Electrical potentials recorded from the scalp in response to auditory signal were first described in 1939 by Davis and colleagues. Auditory evoked potentials can be divided into two categories: transient, or onset potentials and sustained potentials. Neural units generating transient potentials are onset sensitive, and respond to the onset of the stimulus. Jewett (1970) demonstrated that neural responses could be recorded from the brainstem pathways of cats. Jewett, Romano and Williston (1970) recorded ABR in humans and reported that responses consisted of 5 peaks occurring within 7 ms of stimulation.

ABR is an electrophysiological measure used for assessing hearing sensitivity in individuals for whom conventional behavioural method will be difficult to perform. It is also used for identification of neurological abnormalities of the eighth nerve and auditory pathways of the brainstem. Hearing screening of newborn infants began in 1960s (Downs & Sterritt, 1967). Clinical application of the ABR in children appeared over thirty years ago (Hecox & Galambos, 1974). New born auditory screening is a major clinical application of the ABR. The different stimuli used to record ABR are click, tone burst and speech. Click with duration of 100μs is most commonly used for ABR measurement. Click is a broad band stimulus which activates wide range of area in the basilar membrane. There is a lack of agreement among different investigators regarding the frequency region most important for generation of click ABR, i.e., whether it reflects activation of 1000 to 4000 Hz region, 4000 to 8000 Hz region or 2000 to 4000 Hz region (Balfour, Pillion & Gaskin, 1998; Eggermont & Don, 1980; Stapells, 1989). Click ABR corresponds best to the zone of hearing between 500 Hz to 4k Hz. Often ABR testing employs clicks to assess high frequency hearing and tone burst to assess low frequency hearing (Hood, 1998; Goldstein & Aldrich, 1999; Sininger & Cone-Wesson, 2002).

In persons with high frequency hearing loss, the portion of the cochlea contributing to click ABR is different from normal hearing individuals. It varies as a function of response component and stimulus intensity. Wave I reflects activity from basal region and wave V from apical region. Also at higher intensity levels, spread of activation is noticed towards the apex whereas at lower intensity levels, activation is towards the basal region. Tone burst ABR is preferred to elicit frequency specific response from the auditory system especially in infants and children. Tone burst signal have sufficiently rapid onsets to elicit ABR effectively and at the same time maintaining relatively well-defined frequency specificity. Several studies have compared pure-tone thresholds and tone burst-evoked ABR thresholds (Kodera, Yamane, Yamada & Suzuki, 1977; Munnerley , Greville, Purdy & Keith, 1991; Purdy & Abbas, 2002; Stapells, 2000; Suzuki & Horiuchi, 1977). The agreement between the two threshold measures suggests that, tone burst-evoked ABR thresholds can be used to predict the magnitude and configuration of hearing loss (Suzuki, Kodera & Kaga, 1982). Significantly lower signal-to-noise ratio Tone-burst ABRs causes narrower peak excitation on the basilar membrane and also results in a less synchronized neural response and an overall smaller number of neurons responding (Hall, 2006). It has been noticed that stimuli at different frequencies and levels can yield very different wave morphologies.

Hurley, Hurley and Berlin (2005) compared the 500 Hz

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tone burst and click evoked ABR in 305 infants with conceptional age from 33 weeks to 74 weeks. Absolute latencies of wave V at 55, 35, and 25 dB nHL were measured. Data obtained from this study provided age equivalent norms for 500 Hz tone burst. They concluded that Wave V latency in response to 500 Hz tone burst decreased with age and did not stabilize by 70 weeks conceptional age.

To estimate the infants hearing sensitivity using behavioural response is a difficult task. The disadvantage of Behavioural Observation Audiometry is that, it is difficult to eliminate tester bias. Behavioural responses of infants and young children reaches extinction quickly without reinforcement, and a wide variety of responses are noted in youngsters.

Evoked potentials are essential portion of audiologic evaluation mainly in these difficult to test subjects. However, one of the commonly used traditional evoked potential is limited to click ABR only. Click stimuli provides an estimation of auditory functioning in a broad frequency range between 1000 to 4000 Hz. A complete evoked potential evaluation must contain reliable ear specific and frequency specific information. Frequency specific ABR using brief tone is a better choice to get the contour of hearing loss.

Frequency-specific ABR test is universally recommended to determine the thresholds in infants who do not pass newborn hearing screening (Joint Committee on Infant Hearing, 2000). However important variable in the interpretation of ABR tracings, especially in premature infants, is the effect of maturation on the waveforms. The effect of maturation in infants is significant, and with proper normative, misinterpretation of peak wave latencies can easily be avoided. Common paradigm to assess more frequency-specific hearing includes tone bursts with a Blackman windowing function (Gorga, Kaminski Jesteadt & Neely, 1989; Gorga, Kaminski, & Beauchaine, 1988). Several studies have been conducted to see the agreement between pure tone behavioural threshold and tone burst ABR threshold. These agreements suggest for evaluating the magnitude and configuration as it serves as a better choice than click ABR. Threshold information using tone burst can also be used for programming hearing aid.

Age-equivalent ABR norms are important when predicting hearing levels in neonates and infants. Delayed absolute latencies can often indicate other pathologies or unique conditions. Therefore, it is useful to have age equivalent norms for different frequency specific tone burst stimuli to reach a better interpretation. It would be helpful for fitting the hearing aid in children with hearing loss.

Therefore, the present study was carried out with the aim of studying the effect of age on tone burst ABR in infants; to see the maturational changes of tone burst ABR in infants by documenting wave V latency changes of 500 Hz and 4000 Hz TB; to compare difference in latency across 500 Hz and 4000 Hz at different intensity levels (70 dB nHL, 50 dB nHL, 40 dB nHL & 30 dB nHL). The study also aimed to compare the effect of intensity on wave V latency at each frequency separately.

Method

Participants

The study was conducted on 30 infants (30 ears) in the age range of 0 to 12 months. Thirty infants were further subdivided into 2 groups based on their age as 0 to 6 months (15 ears) and 6 to 12 months (15 ears). All the infants had normal otoscopic examination indicating absence of external and middle ear pathology. They were healthy with no symptoms of cold or ear discharge at the time of assessment. They had no complaints and prior histories of any high risk factors, neurological symptoms. All the infants had age appropriate minimum response levels in behavioural observation audiometry, normal outer hair cell functioning ensured by recording TEOAEs and normal hearing sensitivity ensured by recording ABR.

Test Environment

Testing was carried out in a sound treated room where ambient noise levels were within the specified limits as per ANSI S3.1 (1991). The test room was made comfortable enough for the infants in terms of temperature and light.

Procedure

Case history: Detailed information regarding the history of prenatal, natal and postnatal medical conditions was secured for all the infants. A detailed report regarding the auditory behaviour of the infants at home for various environmental sounds like calling bell, pressure cooker, whistle etc were obtained from the parents or caregivers.

High risk register: Medical reports were reviewed to make sure that all the infants were devoid of various risk factors and other medical conditions which can affect auditory system. The modified high risk register developed by Anitha and Yathiraj (2001) was administered to rule out the high risk factors for hearing impairment in infants.

Otoscopic examination: The visual examination of the ear canal and the tympanic membrane of the infant's ear were done using a hand held otoscope. This was done to rule out the presence of wax, foreign bodies in the ear canal and/ or tympanic membrane pathologies.

Behavioural observation audiometry (BOA): The behavioural responses (minimum response level) of the infants were observed in the free field condition using warble tones from 500 Hz to 4000 Hz separated in octaves and for speech stimuli. The lowest levels of presentation of each of the stimuli, at which the subject exhibited some sort of auditory behaviour was noted down.

Tympanogram and Acoustic reflex measurements: The tympanograms were recorded over a pressure range of +200 to - 400 daPa with probe tone frequency of 226 Hz or 1000 Hz. For infants till the age of 6 months, 1000 Hz probe tone was used and for infants above 6 months of age, 226 Hz probe tone frequency was used, with pump rate of 200 daPa /s. To see for the presence of acoustic reflex, Ipsi lateral acoustic reflex thresholds were obtained using broad band noise.

Transient evoked otoacoustic emissions (TEOAEs): TEOAEs were obtained using ILO - V6 instrument with a foam tip positioned in the external auditory canal so as to give a flat stimulus spectrum across the frequency range. Stimuli were clicks with a band pass filter encompassing 500 Hz - 6000 Hz. The duration of rectangular pulses (click) was 80μs. The responses considered were based on the reproducibility and signal to noise ratio (SNR). The overall SNR of greater than or equal to + 3 dB and reproducibility of greater than 50% were considered (Dijik & Wit, 1987) for the presence of otoacoustic emissions.

Auditory Brainstem Response: ABR was recorded using single channel for all the infants using IHS Smart EP system. Initially electrode sites were cleaned with the help of skin preparing gel. Electrodes were placed on the recording sites with the conducting paste and then fixing them with the help of surgical tape. It was ensured that the independent electrode impedance was roughly equivalent or < 5 kOhm and inter electrode impedance was within 2 kOhm at the start of the test. If click ABR wave V was clearly seen at 30 dB nHL or 40 dB nHL and if these results correlated with behavioural observation audiometry, then the infants were considered to have normal hearing sensitivity. ABR was recorded using 500 Hz and 4000 Hz tone bursts of 2-0-2 cycles with black man envelope at 4 intensity levels 70 dB nHL, 50 dB nHL, 40 dB nHL and 30 dB nHL for each subject in both the groups. Tone bursts were presented at the repetition rate of 11.1/s using alternating polarity through ER- 3A insert ear phones. At each intensity level, tone burst ABR was recorded twice for replicability.

Analysis

To arrive at the goal, quantitative and qualitative analysis was done. Qualitative analysis was done based on the simple visual inspection of wave V for 500 Hz and 4000 Hz tone burst at 70 dB nHL, 50 dB nHL, 40 dB nHL and 30 dB nHL for each subject in both the groups. Quantitative analysis was done by obtaining wave V latency values for 500 Hz and 4000 Hz tone burst Sfrequencies at 70 dB nHL, 50 dB nHL, 40 dB nHL and 30 dB nHL for both the age groups. The obtained data for two TB frequencies and 4 intensities across age groups were compared using appropriate statistical analysis.

Results and Discussion

Qualitative Analysis of Tone Burst ABR Wave forms

Tone burst ABR waveforms which are recorded are qualitatively analysed separately for each tone burst frequency and for each age group. The ear from which tone burst ABR recorded was randomly selected.

Qualitative Analysis of 500 Hz tone burst ABR waveforms in Group I: Qualitative analysis of 500 Hz tone burst evoked ABR obtained in group I (15 infants- 15 ears) at different intensity levels revealed that: Wave V could be recorded in all 15 infants (100%) upto 40dB nHL but it could be recorded till 30 dBnHL only in 10 (66.6%) infants and the morphology of the wave recorded using 500 Hz tone burst was poorer with decreasing intensity.The 500 Hz tone burst ABR wave form at different intensity levels recorded in one of the infants from group I is given in Figure 1

500 Hz tone burst at different intensity levels in one of the infants of Group I: Qualitative analysis of 4000 Hz tone burst ABR waveforms in Group I: Qualitative analysis of 4000 HZ tone burst ABR obtained for group I at different intensity levels revealed that Wave V could be recorded in 15 infants (100%) up to 40 dB nHL and could be recorded only in 12 infants (80%) till 30 dB nHL. The 4000 Hz tone burst ABR wave recorded at different intensity levels in one of the infants from group I is given in Figure 2

It can be observed from the above figures (1 & 2), that the morphology of the tone burst ABR becomes better and clearer with increasing frequency of the stimulus. Morphology of the 4000 Hz tone burst evoked ABR waveforms was better compared to 500 Hz tone burst evoked ABR and the waveforms of 500 Hz tone burst ABR had relatively broader peak.

Qualitative analysis of 500 Hz tone burst ABR wave forms in Group II: Analysis of 500 Hz tone burst ABR obtained from Group II (15 infants- 15 ears) at different intensity levels revealed that wave V could be recorded in all 15 infants (100%) upto 40 dB nHL but only in 11 infants (73.3%) till 30 dB nHL. The 500 Hz tone burst ABR wave at different intensity levels in one of the infants from Group II is given in Figure 3

Qualitative analysis of 4000 Hz tone burst ABR wave

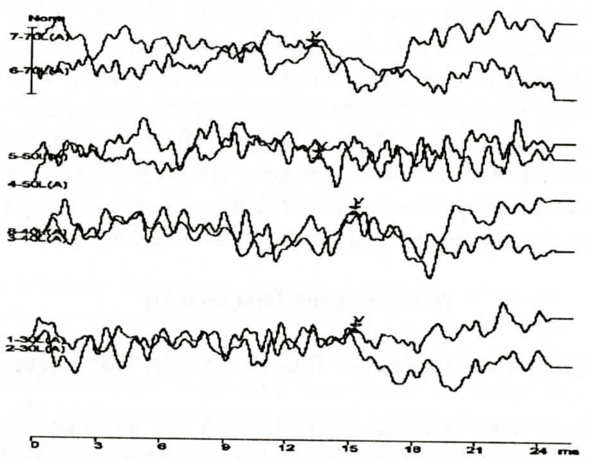

Figure 1: Waveforms showing wave V latency recorded for 500 Hz tone burst at different intensity levels in one of the infants of Group I.

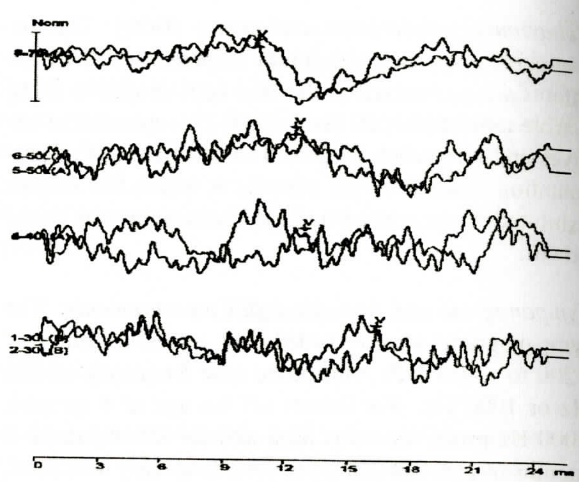

Figure 3: Waveform showing wave V latency recorded for 500 Hz tone burst at different intensity levels in one of the infants from Group II.

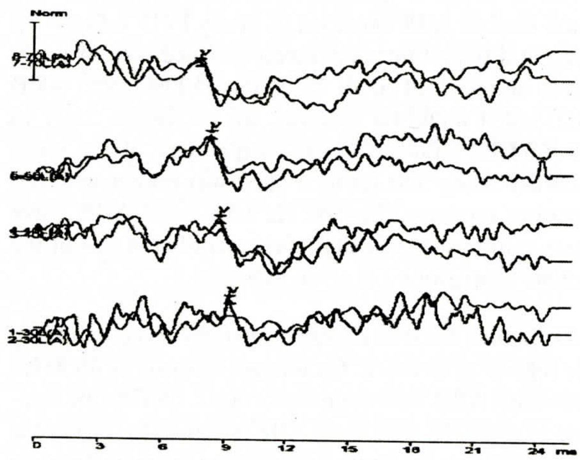

Figure 2: Waveforms showing wave V latency recorded for 4000 Hz tone burst at different intensity levels in one of the infants from Group I.

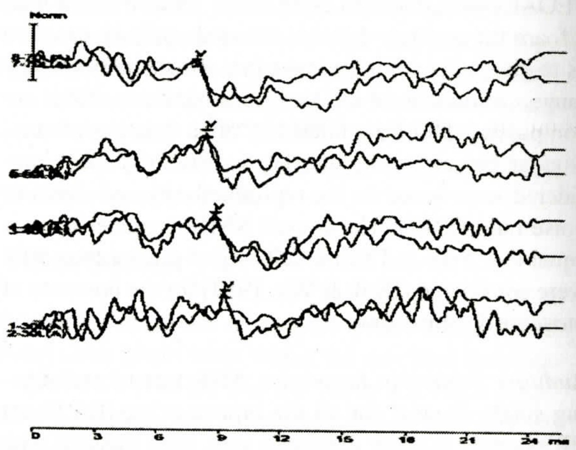

Figure 4: Waveform showing wave V latency recorded for 4000 Hz tone burst at different intensity levels in one of the infants from Group II.

forms in Group II: Qualitative analysis of 4000 Hz tone burst ABR obtained from Group II (15 infants- 15 ears) at different intensity levels revealed that Wave V could be recorded in 15 infants (100%) upto 40 dB nHL and 14 infants (93.3%) had wave V till 30 dB nHL. The 4000 Hz tone burst ABR wave form recorded at different intensity levels in one of the infants from Group II is given in Figure 4.

As observed in Group I, the morphology was poorer with broader peak at 500 Hz tone burst ABR when compared to 4000 Hz tone burst ABR. It can also be noted that wave morphology was better in group II than in group I.

Quantitative Measurements

Quantitative measurements were done to compare the difference in wave V latency with change in age, frequency and intensity. Tone burst ABR obtained from 15 infants in group I and 15 infants in group II were compared in terms of the latency of the wave V. Wave V latency of TB ABR recorded using 500 Hz and 4000 Hz at 70 dB nHL, 50 dB nHL, 40 dB nHL and 30 dB nHL were analysed using Statistical Package for the Social Sciences (SPSS) version 16 software.

Comparison of wave V latency values at different intensities, across age groups using different tone burst frequencies: The mean, standard deviation and range for wave V latency at each age group independently at different intensities using different tone burst frequencies.

As it can be seen in Table 1, there is a specific trend seen in mean wave V latency values. It can be observed that, the mean latency value is higher for group I (0-6 months) compared to group II (6- 12 months). It can also be noted from Table 1 that, the mean latency is

Table 1: Mean, Standard deviation (S.D) and Range of Wave V latency in 'ms' across age groups for different tone burst frequency

Toneburst Frequencies	Intensities (dB nHL)	Wave V latency (ms)					
		Group I			Group II		
		Mean	S.D	Range	Mean	S.D	Range
500 Hz	70	12.20	0.85	11.05-13.15	10.28	0.63	8.97-11.10
	50	13.58	0.67	12.60-15.45	11.40	0.58	10.53-12.46
	40	14.59	0.83	13.50-15.70	12.30	0.58	11.50-13.35
	30	16.00	0.97	14.75-17.50	13.39	0.91	12.55-15.60
4000 Hz	70	7.52	0.42	6.90-8.35	6.92	0.38	6.50-7.70
	50	8.26	0.49	7.20-9.30	7.50	0.39	6.85-8.20
	40	8.77	0.68	7.75-10.25	8.20	0.58	7.25-9.20
	30	9.72	1.53	8.30-12.80	8.76	0.42	8.12-12.80

higher at low frequency, i.e. 500 Hz and lower at 4000 Hz in both the groups. As the intensity level decreases from 70 dB nHL to 30 dB nHL, the mean latency value was found to increase in both the groups.

Mixed analysis of variance (Mixed ANOVA) was done to see the significant interaction across age groups, tone burst frequencies and intensities for wave V latency measures. The results revealed a significant interaction across age groups [$F (1, 17) = 52.97$, $p < 0.05$], across frequencies [$F (1, 17) = 1010.15$, $p = 0.001$], across intensities [$F (3, 51) = 147.45$, $p < 0.05$], across age groups and frequencies [$F (1,17) = 26.04$, $p < 0.05$], across age groups and intensities [$F (3,51) = 1.341$, $p < 0.05$] and across frequencies and intensities [$F (3, 51) = 12.227$, $p < 0.05$]. There is no significant interaction across age groups, frequencies and intensities [$F (3, 51) = 0.301$, $p > 0.05$].

Effect of intensity on wave V latency at each tone burst frequency on each age group: As mixed ANOVA showed significant interaction of wave V latency measures across intensities, repeated measure ANOVA was done for each age group independently to see the effect of intensity on wave V latency at each tone burst frequency. There was significant difference in wave V latency across intensities for Group I at both 500 Hz [$F (3, 27) = 54.03$, $p< 0.05$] and 4000 Hz [$F (3,33)= 29.27$, $p < 0.05$] tone burst frequencies. Group II also showed a significant difference in wave V latency across intensities for 500 Hz [$F (3,39) = 140.76$, $p < 0.05$] and 4000 Hz [F (3,30= 50.57, $p < 0.05$)] tone burst frequencies.

As repeated measure ANOVA showed significant difference in wave V latency across intensities when 500 Hz and 4000 Hz tone burst frequency was used for group I and group II, further analysis was done using Bonferroni's multiple pair wise comparison test, to see between which two intensities, latency of wave V differ significantly. The results of the Bonferroni's multiple pair wise comparison test show that when 500 Hz tone burst frequency was used there was intensity effect seen with significant difference across all the 4 different intensities in both group I and II ($p<0.05$). Similarly when 4000 Hz tone burst frequency was used, there was significant difference across all the 4 different intensity levels from 70 dB nHL to 30 dB nHL in both age group ($p<0.05$).

In the present study there was effect of intensity on wave V latency at 500 Hz and 4000 Hz on Group I and Group II. It was found that there was an increase in latency with decreasing intensity from 70 dB nHL to 30 dB nHL. Similar trend is observed in both Group I and Group II at both frequencies (500 Hz & 4000 Hz). Study done by Werff, Prieve and Georgantas (2009) compared latency intensity function in infants and adults. They have reported that the slopes of the adult latency intensity functions at 2000 Hz (61 μs/dB) and 4000 Hz (45μs/dB) were similar or identical to those for infants at the same frequencies. They also observed that at 500 Hz, the adult slope was slightly shallower (80 μs/dB) than the infant slope.

Beattie (1998) studied ABR on 40 normal hearing subjects for both air-conducted and bone-conducted clicks at intensities of 55, 40, 30, 20, and 10 dB SL. Both bone conduction and air conduction click exhibited increase in latency as the intensity decreased to 10 dB SL. Similarly Fausti, Olson, Frey, Henry and Schaffer (1993) studied latency intensity function using 8 kHz, 10 kHz and 14 kHz tone burst ABR in 14 adults. Result showed shift in response latency for all the frequencies, shift of 0.02 ms to 0.03 ms/ dB was observed.

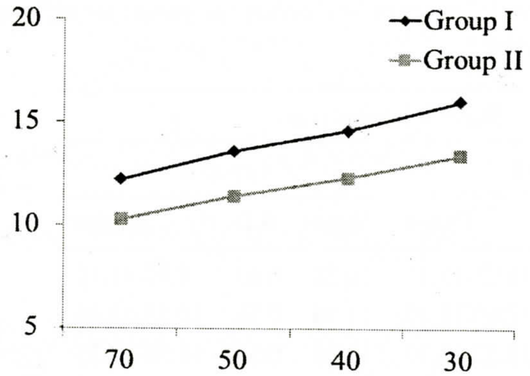

Figure 5: Changes in wave V latency at 500 Hz tone burst in both Group I and Group II.

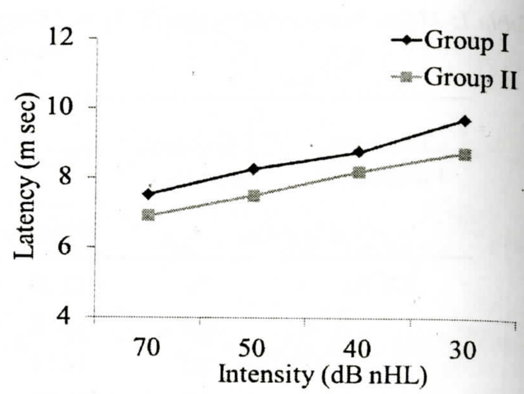

Figure 6: Changes in wave V latency at 4000 Hz tone burst in both group I and group II.

Effect of tone burst frequency on wave V latency at each age group at each intensity: As mixed ANOVA showed significant interaction of wave V latency measures across tone burst frequencies, repeated measure ANOVA was done to see the effect of tone burst frequency on wave V latency at each age group. Results showed that, there was significant difference in wave V latency between tone burst frequency across intensities for Group I [$F(1, 8) = 1095$, $p< 0.05$] and Group II [$F(1, 7) = 275.34$, $p < 0.05$].

Further analysis was done using paired t test, to see at which intensities, latency of wave V differ significantly between the two tone burst stimuli. The results of the paired t test showed that there was a significant difference between wave V latency when 500 Hz and 4000 Hz tone burst were used at all the 4 different intensities from 70 dBnHL to 30 dBnHL for both Group I and Group II ($p<0.05$). It was found that wave V latency was significantly more for 500 Hz tone burst compared to 4000 Hz tone burst in both, Group I and Group II. Studies related to latency changes with frequency have reported the similar results. Suzuki, and Horiuchi (1977) reported that when toneburst stimuli is presented in quiet, the latency and amplitude changes are more for low frequency tones.

Similarly, Gorga et al. (1988) evaluated tone burst ABR in 20 normally hearing subjects for a wide range of frequencies (250-8000 Hz) and levels. Findings suggest that, there was decrease in wave V latencies with increase in both frequency (250 - 8000 Hz) and levels (20 to 100 dB SPL). Reason for increase in wave V latency with decreasing frequency was given by Gorga et al. (1988), reported that decrease in wave V latency with increase in frequency while level is held constant could be due to difference in stimulus rise time. States that increase in latency might be due to longer rise time used in low frequency, and also as frequency decreases, place of maximum excitation shifts towards the apical end of the cochlea. Slop of latency frequency function decreases as level is increased, indicates that latencies are less dissimilar for different frequencies at high levels. They concluded that this pattern could be due to greater effective spread of excitation for low frequency stimuli than high frequency stimuli. Likewise decrease in wave V latency with increase in level while frequency is held constant could result from a basal spread of excitation.

Effect of age on wave V latency at each tone burst frequency: As there was significant interaction seen between age groups when mixed ANOVA was done, to see the effect of age on wave V latency at different tone burst frequencies and at each intensity levels, MANOVA was done for both age groups. Results showed that there was significant difference in wave V latency between groups when 500 Hz [$F(1, 17) = 57.20$, $p < 0.05$] and 4000 Hz [$F(1,17)= 13.80$, $p < 0.05$] tone burst was used. Further analysis of MANOVA using pair wise comparison was done to see at which two intensities, latency of wave V differ significantly across groups for both tone burst frequencies. The results showed that when 500 Hz tone burst was used there was a significant age effect seen on latency at all intensities ($p<0.05$). When 4000 Hz tone burst was used, there was age effect seen with significant difference between Group II and II at 70dB and 50dB intensity levels but there was no significant age effect seen at intensity levels of 40dB and 30dB ($p < 0.05$).

Result of the present study shows that with increase in age there was change in 500 Hz wave V latency in all the intensity levels (70 dB nHL, 50 dB nHL, 40 dB nHL & 30 dB nHL), where as in 4000 Hz change in wave V latency was observed only for higher intensities (70 dB nHL and 50 dB nHL), not for lower intensities (40 dB nHL & 30 dB nHL) or when it reaches near threshold changes in latency with age decreases. Also it can be observed that decrease in wave V latency was more for 500 Hz TB with increasing age compared to 4000 Hz as shown in the Figure 5 and 6.

The results of the present study support the study done by Teas, Klein and Kramer (1982) using filtered click stimuli of 1 kHz, 2 kHz, 4 kHz and 8 kHz recorded ABR in infants from 4 to 60 weeks. They reported wave v latencies at 60 weeks of gestational age age match adult values only for 1 kHz at 50 dB and not at 30 dB, largest latency difference between adult and infants were observed for higher frequencies (2, 4 & 8 kHz) at 60 weeks of age.

Similarly another study done by Ponton, Eggermont, Coupland and Winkelaar (1991) reported that at low frequency TB wave V latency stabilizes by 23 to 24 months post birth. Werff et al. (2009) reported that, infants at 3 months of age showed longer latency difference compared to adults at 500 Hz tone burst stimuli. Study done by Hurley et al. (2005) in infants support the present result where they showed that, 500 Hz tone burst latency decreases with age and not stabilized by 70 weeks of conceptional age. The study also showed that, wave V latency for the 500 Hz AC-TB ABR followed a predicted decrease in latency with age across the age range from 33 to 74 weeks of conceptional age mainly at 55 and 35 dB nHL.

Werner, Folsom and Mancl (1993) also showed using tone burst of 1, 4, and 8 kHz, larger decrease in latency was observed between 6 months and adults and smaller decrease between 3 months to 6 months. Similar to the present results at 4 kHz, there was a significant age and level interaction, also significant difference between 3 months and older listeners at 20 dB HL and significant difference between infants and adults at 30 and 40 dBHL was noticed. Reason for less latency shift with increasing age in the present study could be similar to the study done by Ponton et al. (1991) studied frequency specific maturation of the eight nerve and brainstem auditory pathway using derived ABR in infants and young children (2 weeks post term to 9 years) and adults. Both full term and premature infants ranging from 29 to 42 weeks were included for the study. They reported that mid frequency channels of the VIII nerve and auditory brainstem matured faster and earlier than responses from either very low or very high frequency channels.

Conclusions

Finally it can be inferred from the present study that changes in age causes shift in wave V latencies for 500 Hz tone burst at all the intensities and for 4000 Hz shift was observed only for 70 dB nHL and 50 dB nHL. Compared to 500 Hz tone burst, 4000 Hz tone burst gave better morphology and lower wave V latency. This study supports that use of tone burst ABR is helpful in finding frequency specific threshold in infants. Also by seeing the latency change maturation of the auditory system can easily be understood. Present study was conducted in 30 infants (30 ears) only. The study can be conducted further on more number of infants. Comparison was made only on 2 age groups, can be conducted considering higher age groups and also tone burst frequency taken for the present study is limited to 500 Hz and 4000 Hz, further study using more frequencies can be carried out.

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