

Original Research Article

Effect of age on acoustic reflex thresholds in neonates and infants with normal hearing

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ABSTRACT

Background: High frequency (1000 Hz) probe tone holds substantial promise for carrying out acoustic reflexes in neonates and infants. A limited number of studies indicates that acoustic reflex thresholds (ART) also change significantly with age as the newborn hearing system matures. However, there is a need for obtaining more data before using it in a clinical population. The aim was to investigate effect of age of infants on ARTs. Effect of activator signal was also explored.

Methods: ARTs were monitored using a 1 kHz probe tone for the 500 Hz, 1 kHz, 2 kHz, and 4 kHz pure tone activators in neonates and infants in the age range of 6 to 8 weeks were analysed.

Results: The mean ARTs for neonates were lower compared to infants. Results of repeated measure ANOVA showed that there was a statistically significant age effect. Also, ARTs for high frequency activator signals were significantly higher than the ARTs for low frequency signals.

Conclusions: The acoustic reflexes can be elicited for 500, 1000, 2000, and 4000 Hz when monitored using a 1000 Hz probe tone. There is an effect of age and activator signal on the acoustic reflex threshold. The data obtained in the present study can serve as normative for 0-1-week neonates and 6-8-weeks infants.

Keywords: Acoustic reflex thresholds, Neonates, Infants, Normal hearing

INTRODUCTION

World health organization in 2018 estimated that about 6.3% people are suffering from substantial hearing loss in India.¹ Of this, a large percentage is constituted by children between the ages of 0 to 14 years. A study done in a North-Western part of India revealed a high incidence of hearing impairment i.e., 4 per 1000 of neonates.² These findings indicate that there is a significant need to accurately identify hearing impairment in neonates and infants so that the appropriate management can be initiated early, otherwise it can have a significant effect on the speech and language development.

The position statement of joint committee for infant hearing (JCIH, 2019) states that the principal rule is to provide all the infants with an access to hearing screening using a physiologic measure before 1 month of age.³ The infants who do not surpass the initial hearing screening and the ensuing rescreening should have appropriate audiological and medical evaluations to confirm the presence of hearing loss before 3 months. JCIH recommends a separate protocol for infants below 1 month of age who are at high risk and those in well-baby nurseries. Auditory brainstem response (ABR) is an integral part of screening babies in neonatal intensive care unit so that neural hearing loss will not be missed for this group. ABR is recommended for infants in the well-baby nurseries if they do not pass the initial screening.

Those infants who do not pass the automated auditory brainstem response (AABR) should undergo a comprehensive evaluation.

The screening rationales behind using AABR are various, it provides objective measurement of auditory system, with ear specific information and it is independent of subject's state (sleeping, awake). Additionally, when used in combination with TEOAEs, it detects auditory neuropathy.⁴ The limitations of using AABR are that it is time consuming, and the cost is high. Another alternative for checking auditory neuropathy is using acoustic reflexes. A review of studies suggest that high frequency probe tone is effective in measuring acoustic reflexes in neonates and young infants. Weatherby and Bennett observed that with probe tone of 440 Hz elicited reflexes in 41.9% of babies while for 500 Hz little higher percentage of reflexes (68.2%) of babies showed reflexes.⁵ For 600 Hz acoustic reflexes were present in 93.3% of babies while it could be recorded from all the ears when the probe tone frequency exceeded 800 Hz. Similar results were reported by Sprague for 660 Hz probe tone. Later studies have also confirmed Weatherby and Bennett's findings that acoustic reflex threshold can be consistently elicited from young infants when a probe tone frequency of 1000 Hz is used.⁵⁻⁹ They reported ipsilateral acoustic stapedial reflexes for 1000 Hz probe tone in 91 to 94 % of neonates with an age range of 0 to 5 days.¹⁰ Kei et al observed acoustic reflexes in 95% of full-term neonates with mean chronological age of 2.5 days when the reflexes were monitored using 1 kHz probe tone.¹¹

Thus, the previous reports on acoustic reflexes suggest that acoustic reflex thresholds can best be elicited by high frequency probe tone (800 Hz, 1000 Hz) rather than 220 or 226 Hz probe tone. Acoustic reflexes can help in screening for sensorineural hearing loss. The advantage of using acoustic reflexes in universal neonatal hearing screening over TEOAEs is that acoustic reflex testing screens for neural as well as cochlear hearing loss. Compared to ABR testing, acoustic reflex testing leads to reduced parental anxiety is less time consuming and is more cost effective. Limited number of studies on acoustic reflex indicates that acoustic reflexes thresholds also change significantly with age as the newborn hearing system matures.^{10,11} However, there is a need for obtaining more data before using it on clinical population. Thus, the present study was designed to investigate the effect of age on acoustic reflex thresholds. The effect of probe tone on tympanometry was also investigated.

METHODS

It was a retrospective study. The data collection at Bharati Vidyapeeth (deemed to be university) school of audiology and speech language pathology during 2011 and 2012 were analyzed.

Participants

Two groups of participants were included in the study. Group I included 60 ears of 30 neonates in the age range of 1 to 7 days and group II included 60 ears of 30 infants in the age range of 6 to 8 weeks. Data of a total of 120 ears were considered for analysis.

Inclusion criteria

Only full-term babies were included in the study. All the babies passed transient evoked otoacoustic emissions and auditory brainstem response screening.

Exclusion criteria

Babies with any known otological and neurological problems or those with any significant prenatal, perinatal or postnatal history were excluded from the study.

Equipment

A calibrated audio screener-a portable ABR and TEOAE's screener was used for performing ABR and TEOAE's. A portable middle ear analyzer was used for recording tympanometry and acoustic reflex threshold.

Procedure

The data was collected individually in the presence of parents or caregiver, in a quiet room. Ethical rules of Bharati Vidyapeeth (deemed to be university) medical college were followed. Informed written consent was taken from the parent/caretaker of all the participants. A detailed history was taken before starting any procedure to rule out any ear related abnormalities. A record was checked for demographic factors including gestational age, birth type, ethnicity, head circumference, birth weight, and APGAR scores before the start of procedure to rule out any chances of abnormality in the participant. Each participant was selected for accessible ear first depending on the position in their mother's lap and the child's comfort, then attempt was made to test for other ear, otherwise data for only one ear was obtained.

Immittance evaluation

The neonates and infants who passed the screening for TEOAEs and ABR procedures were considered for Acoustic reflex threshold estimation. The evaluation was carried out after feeding while in natural sleep or in an awake but quiet state. The most accessible ear was tested first. Initially tympanometry was carried out using 226 Hz and 1000 Hz probe tones. Ipsilateral acoustic reflexes were then tested at 500 Hz, 1000 Hz, 2000 Hz and 4000 Hz. Acoustic reflexes were then monitored using 1000Hz probe tone. Ascending technique was used, starting from 70 dB HL and increasing in intensity by 5 dB steps until acoustic reflexes were observed or a maximum of 105 dB HL was reached. Acoustic reflex threshold was defined

as the lowest intensity at which a change in admittance of 0.02 mho was detected.

The data collected were tabulated and descriptive statistics were calculated for both the groups to find out mean and standard deviation acoustic reflexes. Repeated measures of analysis of variance (ANOVA) with frequency as within subject variable and age as between subject variable was carried out to investigate the effect of reflex eliciting signal and age on acoustic reflex thresholds obtained for 1000 Hz. Post-hoc Bonferroni test was done for pair wise comparison.

RESULTS

Acoustic reflex thresholds were monitored using 1000 Hz probe tone for the 500 Hz, 1 kHz, 2 kHz and 4 kHz pure tone activator. The mean and standard deviation for both the groups are given in Table 1. It was observed that the acoustic reflex threshold was higher in infants when compared to those obtained in neonates. The mean differences in acoustic reflex thresholds for both groups were 10.16 dB HL, 9.34 dB HL, 8.61 dB HL and 10.60 dB HL for 500 Hz, 1 kHz, 2 kHz and 4 kHz respectively. Results of repeated measures of analysis of variance showed that the difference observed was statistically significant effect [F (1, 113)=35.42, p=0.00]. Consequently, the null hypothesis that there was no difference in acoustic reflex thresholds of neonates and infants is rejected.

Table 1: Mean and standard deviation for acoustic reflex thresholds.

Reflex activating signal (Hz)	Neonates			Infants		
	N	Mean (dB HL)	SD	N	Mean (dB HL)	SD
500	60	66.75	5.73	60	77.08	9.03
1000	60	69.66	6.02	60	79.08	8.56
2000	60	70.67	5.48	60	79.41	8.88
4000	56	71.52	4.56	56	82.11	9.01

Table 1 also shows that the mean acoustic reflex thresholds increased with increase in frequency of the activator signal in both the groups. Repeated measures of analysis of variance revealed that there was a main effect of activator signal on acoustic reflex thresholds measurement [F (3, 339)=17.99, p=0.00]. Post-hoc Bonferroni was done to see adjustments for multiple comparisons which are shown in Table 2. It can be observed from the Table 2 acoustic reflex thresholds for 500 Hz differed significantly from those obtained for 1000 Hz, 2000 Hz and 4000 Hz. Acoustic reflex thresholds for 1000 Hz did not differ significantly from 2000 Hz but it was significantly different from that of 4000 Hz. Acoustic reflex thresholds for 2000 Hz differed significantly from that of 4000 Hz. Hence, the null hypothesis that there is no effect of activator signal on acoustic reflex thresholds is rejected. There was no

significant interaction between age group and frequency of activator signals [F (1, 113)=0.01, p=0.90].

Table 2: Results of Bonferroni comparison to investigate the effect of reflex activator signal.

Signals (Hz)	500	1000	2000	4000
500		0.001*	0.000*	0.000*
1000			1.000	0.002*
2000				0.033*

Thus, the results of the present study indicates that the activator signal has an effect on acoustic reflex thresholds measurement. The results also indicate that ipsilateral acoustic reflex thresholds increase with increase in age.

DISCUSSION

In the present study all neonates and infants exhibited acoustic reflexes thresholds when monitored using 1000 Hz probe tone. The results of the present study support the results of earlier investigations. Another study used 1000 Hz probe tone in healthy neonates and observed presence of acoustic reflex thresholds in 94% of ears.⁸ Rhodes et al used 2000 Hz probe tone for healthy neonates and reported that 87% of ears presented with acoustic reflex.¹² Kei also reported that all neonates exhibited acoustic reflexes when monitored using high frequency probe tone.¹¹ The 95th percentiles of the acoustic reflex thresholds were 95 dB HL, 85 dB HL and 80 dB HL for the 0.5, 2, and 4 kHz respectively.¹³ Few authors have also reported the presence of acoustic reflex thresholds to be 100% for the ipsilateral side.^{14,15}

Kleindienst et al also observed ipsilateral acoustic stapedial reflexes for 1000 Hz probe tone in neonates with an age range of 12 to 60 hours. The elicitor stimuli used were 500 Hz, 1000 Hz, 2000 Hz, and broadband noise (BBN).¹⁶ They found 97% of the ears had present acoustic reflexes for at least one elicitor stimuli. On a whole 87% of the ears had present reflexes for all elicitor stimuli. Acoustic reflexes across elicitor stimuli showed presence of 91-94%. For tonal elicitors the mean thresholds were found in range of 80-90 dB HL. The mean threshold for broadband noise elicitor was in range of 65 dB HL.¹⁵

In the present study the reflexes could be elicited in all the 60 ears for 500 Hz, 1 kHz, 2 kHz but only in 56 ears for 4 kHz probe tone. A review of literature suggested that even in adults, reflexes could not be elicited at 4 kHz pure tone Jerger et al.²⁰ The absence of reflexes at 4 kHz pure tone frequencies could be because the medial superior Olive is responsive for low frequencies; it is the main component in reflex eliciting arc.

Effect of age

In the present study, the mean acoustic reflex thresholds for the 0.5, 1, 2, and 4 kHz tones for neonates were lower

compared to infants. The mean difference in acoustic reflex thresholds for both groups was 10.16 dB HL, 9.34 dB HL, 8.61 dB HL and 10.60 dB HL for 500 Hz, 1 kHz, 2 kHz and 4 kHz activator tones respectively. Acoustic reflex thresholds obtained in the present study are in close agreement with Mazlan et al reported for 2 kHz pure tone monitored using 1000 Hz probe tone in newborns and at 6-7 weeks babies. Based on the results of a longitudinal study, they reported a mean increase in acoustic reflexes thresholds by approximately 6 dB during 6-week time from birth.¹⁴⁻¹⁶ Swanepoel et al. found age related differences in acoustic reflexes thresholds in neonates who were divided in age ranges of less than 1 week, 1-4 weeks, and 0-4 weeks. There was no significant difference observed with respect to age.¹³

The reason for lower acoustic reflexes thresholds in neonates is the underdeveloped osseous portion of the ear canal in neonates which is found to be more distensible under applied air pressure. Additionally, the increase in acoustic reflex thresholds values may be attributable to the decrease in intensity level with increase in cavity volume in the developing auditory system.⁷

Effect of reflex activating signal

In the present study, there was a main effect of reflex activating signal on acoustic reflex thresholds. Acoustic reflex thresholds increased with increase in frequency. Hirsch et al with high-risk infants group utilized a probe tone of 800 Hz. They found that the mean acoustic reflex threshold was approximately 15 dB lower using the BBN than that using a pure-tone stimulus. The acoustic reflex threshold for tone was 93 dB.^{18,19}

Mazlan et al found mean ipsilateral acoustic reflex threshold for the 2000 Hz stimulus tone at birth was 73.05 dB SPL. When the broadband activator was used as a stimulus, the mean acoustic reflex threshold was 59.39 dB SPL, which is 13.7 dB SPL lower than that obtained using a 2 kHz pure tone stimulus. Thus, studies report a difference in ipsilateral acoustic reflex thresholds between the two activating stimuli using a probe tone of 1000 Hz in newborn babies.^{20,21} The results of the present study show a significant effect of frequency of activator signal on acoustic reflex thresholds monitored using 1000 Hz probe tone.

CONCLUSION

The acoustic reflexes can be elicited for 500, 1000, 2000 and 4000 Hz when monitored using 1000 Hz probe tone. There is an effect of age and activator signal on acoustic reflex threshold. The data obtained in the present study can serve as normative for 0-1week neonates and 6-8-weeks infants.

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