Original Article

High frequency tympanometry findings in neonates and infants with normal hearing- A normative study

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Abstract

Background: Tympanometry is an objective test of middle ear function that is routinely used in audiology practice for the identification of middle ear dysfunction. The present study was carried out toinvestigate results of tympanometry using 1000 Hz probe tone in neonates (1-7 days) and infants (6-8 week). **Methodology:** A cross-sectional study was carried out. Group I included 65 ears of neonates in the age range of 1 to 7 days and Group II included 70 ears of infants in the age range of 6 to 8 weeks. A calibrated GSI Audio Screener was used for performing transient evoked otoacoustic emissions (TEOAEs) and auditory brainstem response (ABR) screening. Madsen-Otoflex 100 middle ear analyzer was used for recording tympanometry. Single component and multicomponent tympanogram was recorded for 1000 Hz probe tone. Type of tympanogram as well as the values for tympanometric peak pressure, peak admittance at tympanic membrane, tympanometric width and equivalent ear-canal volume were recorded. Unpaired-t test was carried out to find significant difference between the two groups with $p < 0.05$ considered as significant value. **Results:** In Group I (neonates), single component tympanometry showed that 95% ears presented with single peaked tympanogram, 3.33% had notched and 1.67% had flat tympanogram for 1000 Hz probe tone. Analysis of multicomponent tympanometry, revealed 1B1G tympanogram in 96.67% and 3B1G pattern in 3.33%. In Group II (infants), single component analyses revealed 85% ears presented with single peak and 15% ears with notched tympanograms. When analyzed for multi component tympanometric pattern, 53.33% in infants presented with 1B1G pattern, 45% showed 3B1G pattern and 1.66% ears had 3B3G pattern. The age has a significant effect on admittance at the tympanic membrane and tympanometric width only. **Conclusion:** The type of tympanogram obtained from healthy middle ear varies depending on age. High frequency probe tone recommended while evaluating neonates and infants lesser than 8 weeks. The data obtained can serve as normative for 0 -1 week neonates and 6-8 week infants.

Keywords: Tympanogram; Tympanometric peak pressure; Tympanometric width

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INTRODUCTION

Assessment of middle ear functioning in young babies is a challenging task for the audiologists. The implementation of neonatal hearing screening programs has increased the number of young babies referred for detailed audiological evaluation and it is of great importance that the hearing of the referred baby is accurately assessed. One of the common problems observed amongst neonates and infants is

occurrence of middle ear infection. It had been reported that 67% of babies referred from a screening program had only middle ear effusion[1]. As conductive pathology may mystify the interpretation of test results it is important to distinguish it from sensorineural pathology. The middle ear system of neonates and infants is mass dominated[2]. Hence, application of tympanometry using low probe tone frequency (226 Hz) to diagnose conductive pathology will not give reliable results[3]. Attempts have been made to evaluate middle ear functions in neonates and infants using 1000 Hz probe tone.[4-8] But still very limited data is available to use it in middle ear evaluation of newborns and young infants.In one of the early investigations using 1000 Hz probe tone, Kei et al[8] observed Type 1, single-peaked tympanogram in a majority of the neonates, Type 2 or flat type tympanogram in 5.7% of the neonates and Type 3 or double-peaked was observed in 1.2% of the neonates. Another study reported normative data for 1000 Hz admittance tympanograms in sixty-five neonatal intensive care graduates (Gestation Age: 37 weeks) and in thirty full-term infants tested at 2-4 weeks who passed an otoacoustic emissions (OAE) screen. They reported a single cut-off value of 0.6 mmho for static admittance is useful for infants up to 4 weeks of chronological age.[5] Mazlan R et al evaluated the high frequency (1000 Hz) tympanometry measures obtained from infants at birth and at 6 to 7 weeks of ageand indicated that the mean uncompensated admittance values at +200 daPa were 1.07 mmho at birth and at 6-7 weeks it was 1.33 mmho.[6] Swanepoel et al[7] evaluated high frequency immittance measurements in infants (0-4 weeks of age range) using a 1000 Hz probe tone. They reported that 8 % were presented with no discernible peaks, 6% tympanograms were double peaked, and 95% of infants showed single peak tympanograms. They further observed that the static admittance values differed significantly across gender and age with the 5th percentile cut-off value of 1.4 mmho. The tympanometric peak pressure values increased with growing age from 140 daPa for 1week neonates of age to 210 daPa for 2-4 weeks neonates. The variations in normative data obtained across studies may be due to the effect of various factors such as pump rate, direction of pressure sweep. Thus, the present study was planned and conducted to establish normative data for 1000 Hz probe tones in neonates and infants and to investigate results of tympanometry using 1000 Hz probe tone in neonates (1-7 days) and infants (6-8 week).

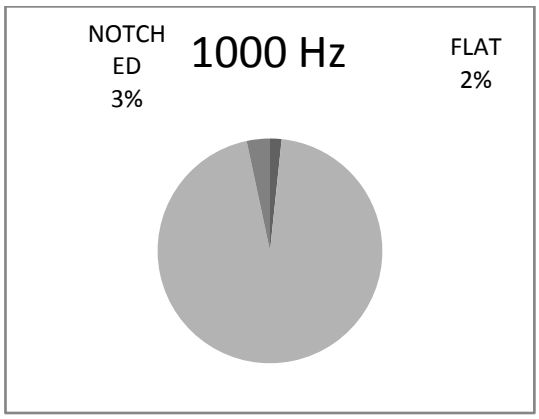
MATERIAL AND METHODS

A cross-sectional study was carried out to investigate the tympanometric peak pressure, peak admittance at tympanic membrane, tympanometric width and equivalent ear-canal volume and tympanometric patterns in 1-7 days babies and in 6-8 weeks babies. Participants were divided into two groups for the commencement of the study, Group I included 65 ears of neonates in the age range of 1 to 7 days and Group II included 70 ears of infants in the age range of 6 to 8 weeks. Data was collected from a total of 120 ears due to non inclusion of failed or dropped ears. Only full term babies were included for the study. It was ensured that the ear canal was free of debris and wax. All the babies included in the study passed transient evoked otoacoustic emissions (TEOAEs) and auditory brainstem response (ABR) screening. Babies with any otological or neurological problem or with any significant prenatal, perinatal or postnatal history were excluded from the study.A calibrated GSI Audio Screener was used for performing ABR and TEOAEs screening. Madsen-Otoflex 100 middle ear analyzer was used for recording tympanometry. The data was collected individually in the presence of parents or caregiver, in a quiet room. 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, birth weight, and APGAR scores before the start of procedure to rule out any chances of abnormality in the participant. The neonates and infants who passed the screening for TEOAEs and ABR procedures were considered for immittance evaluation. Single component and multicomponent tympanogram was recorded for 1000 Hz probe tone. Type of tympanogram as well as the values for tympanometric peak pressure (TPP), peak admittance at tympanic membrane (Y_{TM}), tympanometric width (TW) and equivalent ear-canal volume (ECV) were recorded. Data so obtained was compiled and unpaired-t test was

carried out to find significant difference between the two groups with p <0.05 considered as significant value.

RESULTS

The age of the babies at the time of testing ranged from 0 to 7 days with a mean age of 42.60 hours for Group I and 6 to 8 weeks with a mean age of 6.61 weeks for Group II. In Group I, 65 neonatal ears screened and among them 60 ears that passed TEOAEs and ABR screening were evaluated for tympanometry. In the second group, out of 70 ears, 60 ears which passed TEOAEs and ABR screening were further evaluated for tympanometry. The descriptive statistics for all tympanometric variables were tabulated in table 1.



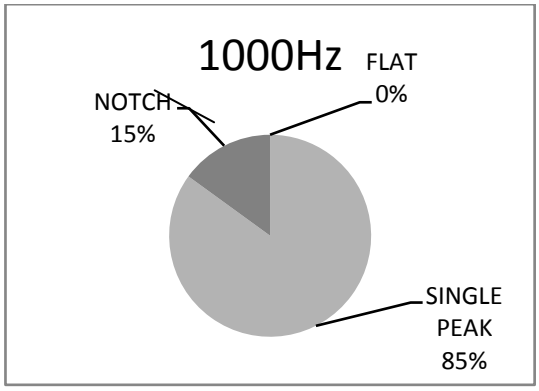
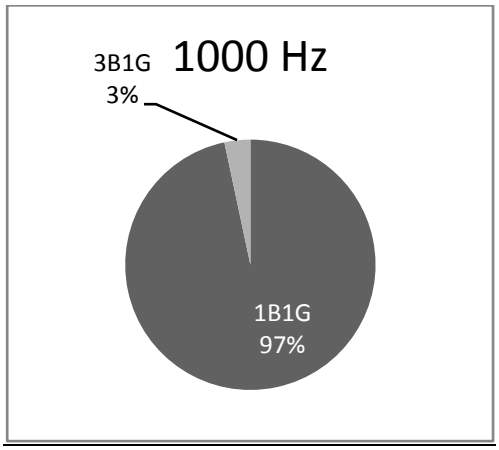


Figure 1: Comparison of single-component tympanometry (Number of ears (in percentage) with single peaked, notched and flat tympanogram in neonates and infants)



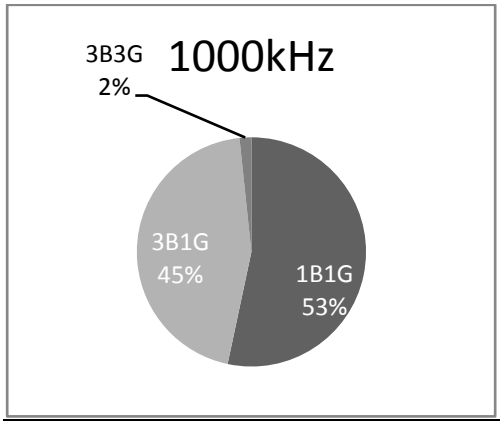


Figure 2:Comparison of multi-component tympanometry (Number of ears (in percentage) with 1B1G, 3B1G, 3B3G tympanometric patterns for 1000 Hz probe tone in neonates and infants)

Single component tympanometry is classified as single peaked, notched and flat tympanograms while multi component tympanometry is classified based on 1B1G, 3B1G, 3B3G, 5B3G type of curves.

In Group I (neonates), single component tympanometry showed that 57 ears (95%) presented with single peaked tympanogram, 2 ears (3.33%) had notched and 1 ear (1.67%) had flat tympanogram for 1000 Hz probe tone. Analysis of multicomponent tympanometry, revealed 1B1G tympanogram in 58 ears (96.67%) and 3B1G pattern in 2 ears (3.33%).

In Group II (infants), single component analyses revealed 51 out of 60 ears presented with single peak and 9 ears with notched tympanograms. A majority of infants had single peaked tympanogram for 1000 Hz and very few showed notched tympanograms. For 1000 Hz probe tone

Table 1: Mean and SD values for 1000 Hz probe tone for different tympanometric variablric I variable in neonates and infants.

Tympanometric* Variables	1000 Hz Neonates		1000 Hz Infants	
	Mean	SD	Mean	SD
TW (in daPa)	124.48	35.24	113.90	1.09
Y_{TM} (in mmho)	0.49	0.20	1.09	0.43
TPP (in daPa)	17.02	21.63	19.31	74.24
ECV (in ml)	0.46	0.06	0.43	0.12

Table 2: Results of 'unpaired-t' test for tympanometric patterns of neonates and infants

Tympanometric variables	**t**	**df**	**Sig 2- tailed**
SC	9.77	118	0.000
TW	2.28	116	0.024
TPP	0.229	116	0.819
ECV	1.726	116	0.087

greater number of infant ears showed notched tympanograms when compared to neonate ears. When analyzed for multi component tympanometric pattern 32 out of 60 ears (53.33%) in infants presented with 1B1G pattern, 27 ears (45%) showed 3B1G pattern and 1 ear (1.66%) had 3B3G pattern. 1000 Hz probe tone resulted in 1B1G in a majority of neonates while in infants nearly equal number of participants had 1B1G and 3B1G pattern. Table 2 shows the results of unpaired-t test for tympanometric variables. A significant effect of age was observed for admittance at the tympanic membrane and tympanometric width but not for tympanometric peak pressure and ear canal volume.Thus, a significant difference observed between neonates (M= 124.8, SD =35.24) and infants (M= 113.90, SD= 1.09), t (116) = 2.28, p = 0.024 for Tympanic width and between neonates (M= 0.49, SD =0.2) and infants (M= 1.09, SD= 0.43), t (118) = 9.77, $p \leq 0.00$ for admittance at tympanic membrane. For tympanometric peak pressure, there was no significant difference observed between neonates (M= 17.02, SD =21.63) and infants (M= 19.31, SD= 74.24), t (118) = 0.229, p =

0.89 as well as there was no significant difference observed between neonates (M= 0.46, SD =0.06) and infants (M= 0.43, SD= 0.12), t (116) = 1.72, p = 0.08.for ear canal volume.

DISCUSSION

Tympanometry is an objective test of middle ear function that has been routinely used in audiology practice for the identification of middle ear dysfunction.[9] The present study investigated the effect of probe tone in both neonates and infants groups and it was found that single component tympanometry revealed more number of ears with single-peaked tympanograms for 1000 Hz probe tone. Multicomponent analysis revealed, with 1000 Hz probe tone 1B1G pattern was more frequently observed in neonates, while in infants there were equal number of ears with 1B1G and 3B1G pattern. These results are in agreement to the results reported by Margolis et al[5] who reported that nearly all of the infants with a mean age range of 3.7 weeks had a single-peaked tympanogram for 1000 Hz probe tone. Similar results were observed by Kei et al[8] who studied healthy neonates in the age range of 1 to 6 days using both 226 Hz and 1000 Hz. Swanepoel et al[7] also reported that 95% of the neonatal ears tested showed single peak tympanograms for 1000 Hz probe tone. Calandruccio et al[10] reported that the typical Vanhuyse patterns observed in the younger infants and adults varied especially at 1000 Hz probe tone frequency. The reason for presence of single peaks in the neonates and infants ear system from the adult system is indicative of mass dominance at high probe tone frequencies and stiffness dominance at low probe frequencies.[11]

We found a statistically significant difference across the groups for admittance at the tympanic membrane (0.49 mmho at birth and 1.09 mmho at 6-8 weeks respectively). These findings are in close relation to Margolis et al[5] who reported a single cut-off value of 0.6 mmho for static admittance of infants up to 4 weeks of chronological age. Another study also found statistically significant increase in peak-uncompensated static admittance values (1.07 mmho at birth and at 6-7 weeks it was 1.33 mmho) for a 2 kHz probe tone.[6] This increase in tympanometric values may be indicative of a change in the tympanic cavity and mastoid, during this early developmental phase.[3] The various structural changes include an increase in the size of the external auditory canal, change in the inclination of tympanic membrane, size of middle ear cavity and mastoid, a decrease in mass of middle ear due to loss of amniotic fluid and change in the overall bone density of ossicles, tightening of the middle ear bone joints, fusion of tympanic ring and development of the bony ear-canal wall in infancy.[12] There was also a statistically significant change in the tympanometric width with age. The present study found that thetympanometric peak pressure was not significantly higher for neonates when compared to infants. Mazlan et al[6] also observed a steady decrease in tympanometric peak pressure values (12.46 ± 44.76 daPa in neonates; -2.08 ± 67.99 daPa for 6-7 weeks infants) across age but they did not find any statistically significant differences with age. They attributed the reason for this to the wide range of SD. Swanepoel et al [7] reported tympanic peak pressure values increased with growing age from 140 daPa for 1week neonates of age to 210 daPa for 2-4 weeks age range but again change was not statistically significant across age. There was no significant change in ear canal volume with age. The data obtained in the present study are similar to the reports of the previous study[13] which reported that the ear canal volume ranged from 0.3 to 0.9 ml in neonates for 1000 Hz probe tone. To summarize, there is an effect of age on admittance at the tympanic membrane and tympanometric width and the results are in accordance with the results of the previous studies. Even parameters like sleeping position, nursing, laying quiet of child may result in false positive peak. An audiologist needs to be vigilant while performing high frequency tympanometry in such a small age range population. The present study suggests that 1000 Hz probe tone should be used while evaluating middle ear of babies younger than 8 weeks. These results are in accordance to the results of the previous studies[14] who advocated the use of 1000 Hz probe tone in infants younger than 5 months. Still more research is required to find normative for Acoustic reflexes thresholds in Indian population to effectively implement in universal newborn hearing screening programmes.

CONCLUSION

The type of tympanogram obtained from healthy middle ear varies depending on the age. The age has a significant effect on admittance at the tympanic membrane and tympanometric width. The data obtained in the present study can serve as normative for 0-1 week neonates and 6-8 week infants in Indian population.

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