Original Research Article

Clinical study on low vs high probe tone frequency tympanometry in children: Rural population

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International Archives of Integrated Medicine, Vol. 3, Issue 10, October, 2016.

Available online at http://iaimjournal.com/
ISSN: 2394-0026 (P) **ISSN: 2394-0034 (O)**
Received on: 27-09-2016 **Accepted on:** 13-10-2016
Source of support: Nil **Conflict of interest:** None declared.
How to cite this article: Y. Kishore Kumar, Ajay Kumar Basod, G. Obulesu. Clinical study on low vs high probe tone frequency tympanometry in children: Rural population. IAIM, 2016; 3(10): 251-258.

Abstract

Background: Hearing impairment is a major problem worldwide, significantly delaying acquisition of speech in children. Unfortunately delayed detection of hearing impairment especially in rural and remote areas, adds a significant burden to the society and the nation. Hence early detection of hearing impairment is imperative and the need of the hour lies in developing an easy, cost effective and reliable method for testing large number of neonates and infants. This study was to assess the effectiveness and utility of Tympanometry as a screening tool for assessment of middle ear pathology in neonates and infants. Middle ear disorders are significantly prevalent in young children.

Aim: Investigating and comparing the results of visual inspection of the tympanic membrane to the results of Tympanometry with traditional probe tone (226 Hz) and high frequency probe tone (678 Hz) in" ears without effusion" and "ears with effusion" and to establish their sensitivity and specificity to detect middle ear disorders as a database in clinical practice.

Materials and methods: Subjects were evaluated for the stable middle ear/ Eustachian tube function. Ears with no sign of effusion in the middle ear on otoscopy were labeled as "ears without effusion" and those who showed the presence of fluid in the middle ear were labeled as "ears with effusion". Blinded to otoscopic ear exam results, Tympanometry was conducted with conventional probe tone of 226 Hz and high probe tone 678 Hz by audiologist using standard procedure.

Results: Otoscopic examination results of ears for all age groups were evaluated and ears without effusion and with effusion were tabulated.

Conclusion: The tympanometric parameters obtained with 226 Hz and 678 Hz probe tones have statistically significant differences in detecting the ears without effusion and with effusion. Compliance values also proved to be statistically different with the different probe tones.

Key words

Tympanometry, Children, Rural, Low vs high probe tone.

Introduction

Hearing impairment is a major problem worldwide, significantly delaying acquisition of speech in children. Unfortunately delayed detection of hearing impairment especially in rural and remote areas, adds a significant burden to the society and the nation. Hence early detection of hearing impairment is imperative and the need of the hour lies in developing an easy, cost effective and reliable method for testing large number of neonates and infants. This study was to assess the effectiveness and utility of Tympanometry as a screening tool for assessment of middle ear pathology in neonates and infants. Middle ear disorders are significantly prevalent in young children. Approximately more than 50% of children are affected by otitis media with effusion in their first year of life and 70 to 90 % children are affected by otitis media with effusion at some time before school age. Recurrent otitis media with effusion can result in mild to moderate hearing loss [1-3]. In these children, audiological diagnosis is challenging and an accurate assessment is important to initiate appropriate rehabilitation strategies. Tympanometry is an objective test for identifying middle ear problems. Conventional 226 Hz probe tone is routinely employed to assess integrity of middle ear and to distinguish conductive from sensorineural hearing loss in older children and adults, but it is known to have little sensitivity. Furthermore, it produces differently shaped tympanograms in infants compared with older children and adults. Middle ear compliance is lower and resistance is higher in infants compared with adults. Moreover, the resonant frequency of the tympanic membrane is much lower in children [4, 5]. Developmental changes in the external and middle ear structures during the first months of life significantly affect the ear canal impedance and reflection coefficient responses. Hence, the middle ear evolves from a mass dominated to a stiffness-dominated system.

This line of understanding and erroneous results with 226 Hz probe tone in infants and poor diagnostic performances in mass dominated middle ear pathologies in adults arose the question of accurate results and instigated the use of high probe tone to assess the mass dominated middle ear system in early months of life.

Despite recent findings and understanding, the use of higher probe tone frequency has not been fully put into clinical practice especially in our country. Hence to highlight the clinical importance of high probe tone frequency in infants the current study was undertaken.

Aim

The study aimed at investigating and comparing the results of visual inspection of the tympanic membrane to the results of Tympanometry with traditional probe tone (226 Hz) and high frequency probe tone (678 Hz) in" ears without effusion" and "ears with effusion" and to establish their sensitivity and specificity to detect middle ear disorders as a database in clinical practice.

Materials and methods

Subjects

This was an experimental design study which included 90 newborns and infants of both genders, with mean age of 14.7 months in the age range of 10 days to 18 months. The selected subjects were born at full term without having any risk factors, outer ear abnormality and head and neck defect. Subjects were divided into three

groups 10 days to 6 months and 6 to 12 months and 12 to 18 months, each group consisting of 15 subjects(in subjects with both ear middle ear effusion, only one ear was selected for the study). Fourth group consisting of 10 adult subjects "without middle ear effusion" and 10 adult subjects" with middle ear effusion" who served as reference for 226 Hz and 678 Hz probe tones.

Instrumentations

Otoscope (Heine)
Bull's Lamp
Head Mirror
Middle Ear Analyzer (GSI 36)

Procedure

Subjects were evaluated for the stable middle ear/ Eustachian tube function. Ears with no sign of effusion in the middle ear on otoscopy were labeled as "ears without effusion" and those who showed the presence of fluid in the middle ear were labeled as "ears with effusion". Blinded to otoscopic ear exam results, Tympanometry was conducted with conventional probe tone of 226 Hz and high probe tone 678 Hz by audiologist using standard procedure. Tympanogram parameters namely, ear canal volume, tympanometric peak pressure and compliance were obtained. The observed results in the respective ears were interpreted using Jerger's classification of tymapnogram and Vanhusyee classification respectively. The study was conducted on the rural population of Chhattisgarh under the supervision of pediatric department.

Analysis

In this statistical study, we carried out descriptive and comparative analysis and found a significant difference between two probe tones to identify middle ear condition of the neonates and young children. The analysis was carried out by the MANOVA p- value at <0.05 level of significance and the mean values were calculated.

Results

Otoscopic and Tympanometric Measures

Otoscopic examination results of ears for all age groups were evaluated and ears without effusion and with effusion are depicted in **Table - 1**.

Table – 1: The four different groups with corresponding age range and number of ears otoscopically classified as "ears without effusion" and ears with effusion".

Groups	Age range	Ears without effusion	Ears with effusion
I	10 days to 6 months	15	15
Ii	6 months to 12 months	15	15
Iii	12 months to 18 months	15	15
Iv	Adults	10	10

Total 110 tympanograms for each probe tone frequency, 226 Hz and 678 Hz were obtained for all age groups. The results of the tympanogram components namely, External Ear Volume, Tympanometric Peak Pressure (TPP) and Compliance for both probe tones are presented in **Table - 2**, which were further descriptively analyzed for better understanding of test findings. The observed results were classified for tympanograms types (Table 3) based on Liden and Jerger classification system for both probe tones. The comparative analysis of the data, between the parameters of probe tones of 226 Hz and 678 Hz was done to determine statistically significant difference. The results from table 2 indicate statistical difference in comparing the two probe tones with the tympanometric measures in ears without effusion and with effusion.

Table - 2: Showing obtained means & standard deviation (in parenthesis) of values of tympanometry measures with 226 Hz and 678 Hz probe tone for all three age groups.

	Groups	Ear canal volume (ml/mmho) (with mean of total subjects		Tympanometric peak pressure (dapa)		Compliance value (ml/mmho)	
Ears without Effusion		226 Hz	678 Hz	226 Hz	678 Hz	226 Hz	678 Hz
	I	0.38(0.6)	0.40 (0.5)	2.91 (39.13)	17.631 (0.3)	0.86 (0.6)	0.68 (0.37)
	Ii	0.35 (0.9)	0.41 (0.3)	2.37 (37.330)	16.907 (0.40)	0.79 (0.9)	0.60 (0.49)
	Iii	0.32 (1.0)	0.41 (0.7)	3.03 (34.36)	13.633 (0.40)	0.82 (0.5)	0.67 (0.46)
	Iv	1.21 (0.7)	0.19 (0.9)	2.37 (41.30)	13.632 (0.52)	0.99 (0.5)	0.69 (1.10)
Ears with Effusion	I	0.27 (1.3)	0.19 (0.9)	2.37 (41.30)	13.632 (0.41)	0.41 (0.7)	0.21 (0.31)
	Ii	0.29 (1.1)	0.23 (0.8)	2.67 (31.90)	11.675 (0.46)	0.39 (0.4)	0.27 (0.36)
	Iii	0.33 (1.4)	0.31 (1.1)	2.96 (39.37)	13.634 (0.26)	0.45 (0.9)	0.34 (0.14)
MANOVA P value at <0.05		**0.001**		**0.005**		**0.010**	

Distribution of tympanogram types

Figure - 1 and **Figure - 2** depict the distribution of tympanogram types according to the visual tympanograms classification system with a 226 Hz and 678 Hz probe tone respectively for the ears without effusion. The Tympanograms in subjects below 18 months, without effusion according to the visual admittance of 678 Hz and 226 Hz probe tone frequencies was as per **Figure – A** and **Figure – B**.

In our study, we found the tympanometry with 226 Hz probe tone, the proportion of single peaked tympanograms increased with age. Conversely the proportion of double peaked tympanograms (which is confusing in the interpretation) increased below the age of 18 months. For 678 Hz Tympanometry, a reverse effect was found. Moreover the use of a 678 Hz probe tone frequency lowered the prevalence of flat and multiple peaks tympanograms in all child groups. **Figure - 3** and **Figure - 4** depict the distribution of tympanogram types with a 226 Hz and 678 Hz probe tone, respectively for blinded ears with effusion.

In our study the tympanometry with 226 Hz probe tone, the proportion of multiple peak tympanograms lowered with increasing age. The occurrence of multiple peak tympanograms increased below the age of 18 months. Tympanograms with 678 Hz probe tone, reverse was found.

Sensitivity and specificity of probe tone

Descriptive analysis from **Figure - 1, 2, 3 and 4** indicated that 45 newborns and infants of all age groups assessed with 226 Hz and results show that out of 45 subjects without effusion, 16 subjects (35.55%) were shown no effusion (normal) and in 45 subjects with effusion 12 subjects (26.67%) were shown with effusion (abnormal).

Whereas with 678 Hz, the results show that out of 45 subjects without effusion, 29 (64.445%) were shown no effusion (normal) and in 45 subjects with effusion, 6 subjects (13.33%) were shown with effusion (abnormal).

Thus, one can infer from **Table - 3** that 678Hz probe tone has higher sensitivity and specificity in detecting middle ear effusion in selected group.

Discussion

The purpose of this study was to compare the usefulness of conventional low frequency (226 HZ) and high frequency (678 Hz) probe tones to detect middle ear disorders. The otoscopic

findings were well correlated with the tympanometric measures obtained with 678 Hz probe tone than with the 226 Hz probe tone for the subjects below 18 months.

Figure - A and Figure - B: shows the Tympanograms in subjects below 18 months, without effusion according to the visual admittance of 678 Hz and 226 Hz probe tone frequencies.

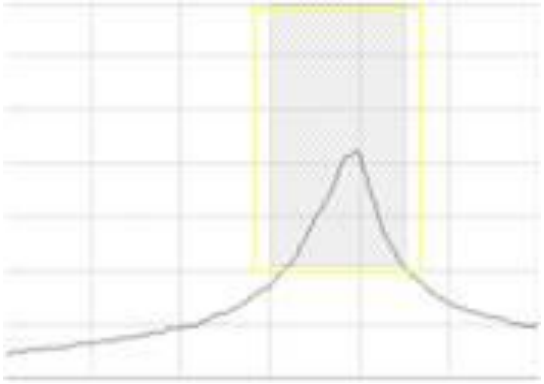

Fig.(A) with 678 Hz

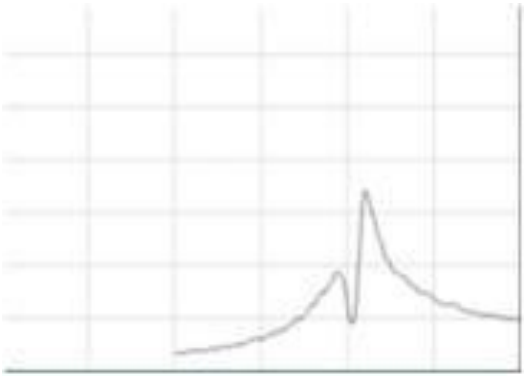

Fig. (B) with 226 Hz

Figure - 1: The distribution of 226 Hz typanogram types of"ears without effusion" for 4 different age groups.

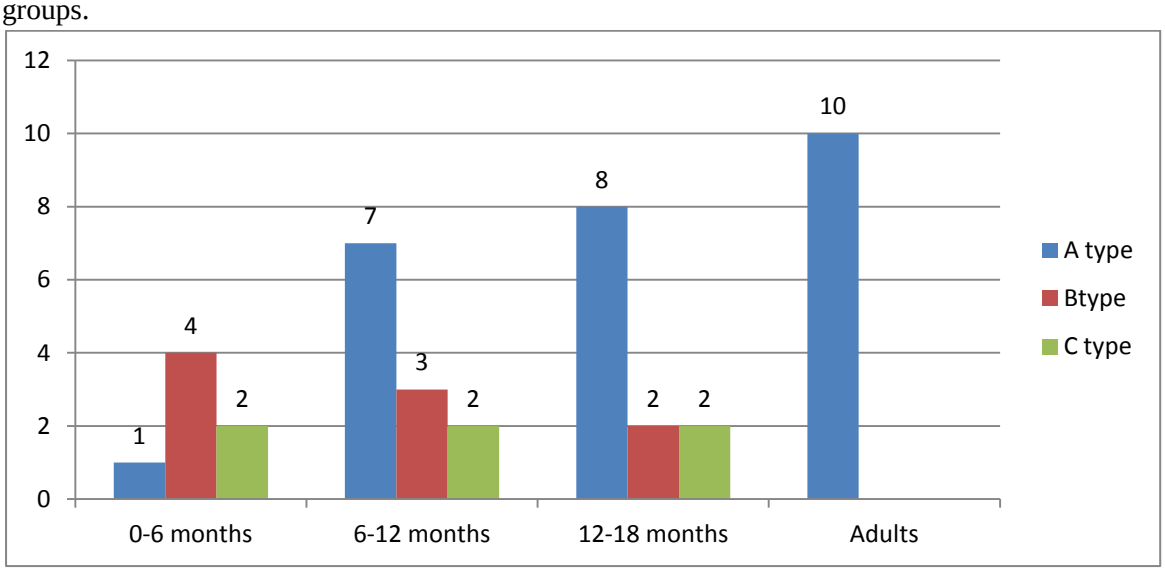

Figure - 2: The distribution of 678 Hz typanogram types of "ears without effusion" for 4 different age groups.

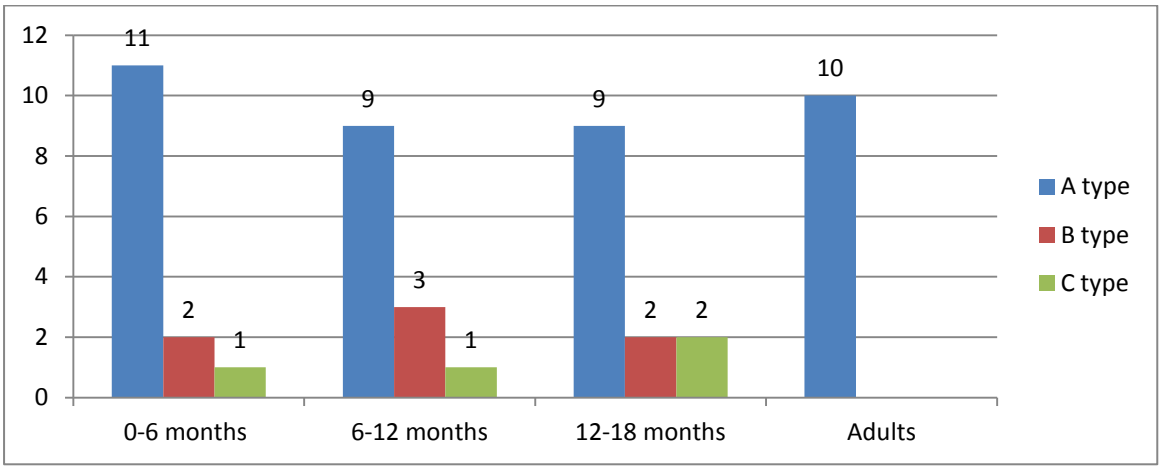

Figure - 3: The distribution of 226 Hz tympanogram types in "ears with effusion" for 4 different age groups.

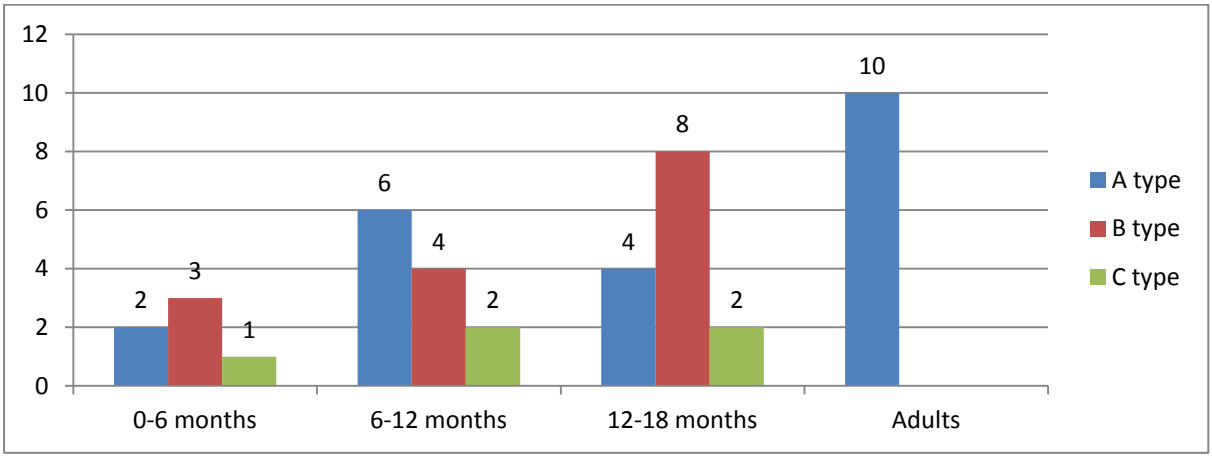

Figure - 4: Distribution of 678 Hz tympanogram types in "ears with effusion" for 4 different age groups.

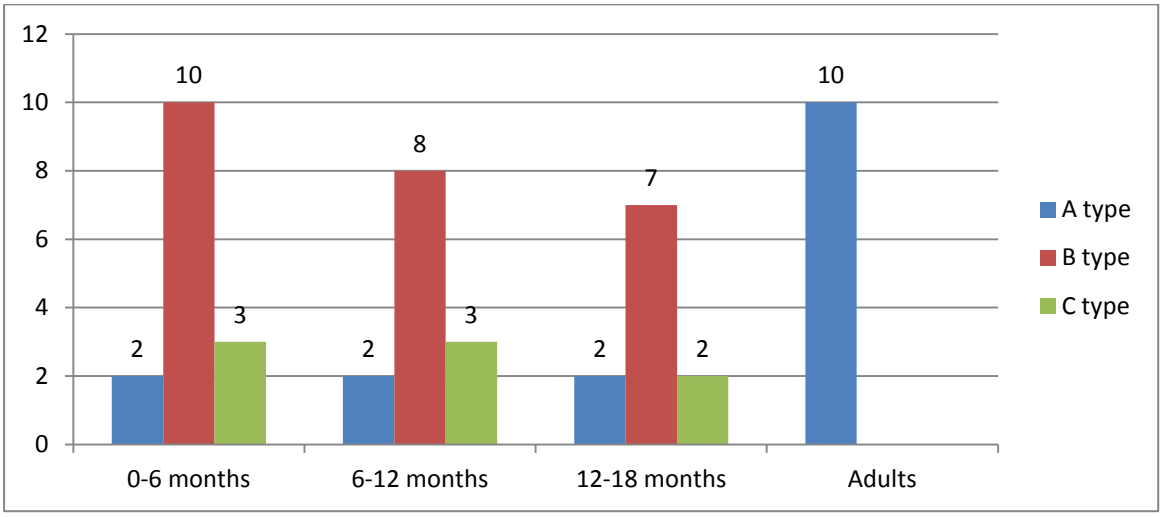

Table – 4: showing sensitivity and specificity of 226 Hz and 678 Hz probe tone in subjects below 18 months of age group.

Test Procedure	Sensitivity (n = 45)	Specificity (n = 45)
226Hz	**38%**	**29%**
678 Hz	**61%**	**89%**

Tympanometric measures

In the present study, the tympanometric mean values for babies "ears without effusion", found were the 0.36 and 0.41 mmho for ear canal volume with the 226 Hz and 678Hz tone. The TPP varied between -91 dapa and 93 dapa, with a mean value of 2.77 dapa for the 226 Hz tone and between -121dapa and 90dapa, with a mean value of 16.07 dapa for the 678 Hz test tone. The compliance values were 0.82 ml with the 226 Hz test tone and 0.65 mohm with 678 Hz [6-9].

Whereas in "ears with effusion" the tympanometric measures obtained were the 0.29 ml and 0.24 mmho for ear canal volume with the 226 Hz and 678 Hz tone. The TPP varied between -106 dapa to -193 dapa, with a mean value of 2.73 for the 226 Hz tone and between -121 dapa and -290 dapa with a mean value of 13.04 dapa for the 678 Hz test tone. The compliance values were 0.41 ml with the 226 Hz test tone and 0.27 mmho with 678 Hz [10, 11].

The measured tympanometric values for the 678 Hz in ears without effusion are similar to values reported by Baldwin, et al. (1995) [3]. However, it differs from values reported by Alaerts, et al. (2007) [1] which may be due to the size of the sample considered, testing conditions, baby movements, sucking at the time of recording or improper sealing of the external auditory meatus etc.

Sensitivity and specificity of probe tones

The present study was to determine the sensitivity and specificity of test tones in detecting the middle ear disorders. The results of **Table - 3** indicate that 678 Hz has higher and 226 Hz has the lower sensitivity and specificity in categorizing the middle ear status. These results are similar to findings of Alaerts, et al. (2007) [1], in which they reported reliable values (91%) with 678 Hz and (35%) with 226 Hz tone. Moreover, the 226 Hz test tone resulted in 58% of false positive results in their study. Thus the results obtained in ears without effusion by this current study can serve as guideline or normative for clinical application.

It is worth noting from this study, that there exists co-relation between subjective (Otoscopic) examination and instrumental diagnosis in determining the middle ear status which is usually considered as superior in identifying the middle ear fluid. Thus it can be concluded that high frequency test tone is better in the detection of middle ear effusion of the newborns and babies up to 18 months of age. However, it must not be interpreted alone, but together with the findings of the otoscope [12, 13].

Limitations of the study

The findings of the present study are limited in generalization, as test was performed on full term healthy young children only and sample size was small. Moreover, mere ears without effusion may not guarantee absence of other middle ear pathologies. Further, we did not perform the ear and gender specific analysis and findings may differ in presence of risk indicators and dimorphic features in absence or presence of effusion.

Conclusions

The tympanometric parameters obtained with 226 Hz and 678 Hz probe tones have statistically significant differences in detecting the ears without effusion and with effusion. Compliance values also proved to be statistically different with the different probe tones. Thus, 678 Hz probe tone could be beneficial in hearing screening and programs like prevention of deafness program in our country. However, this study also emphasizes the importance of skilled professionals in identifying the normal ears and ears with effusion. Recent studies including the current study indicates that the 678 Hz probe tone is recommended for the assessment of infants up to the age of 6 months. But there are very few studies in the literature using tympanometry in newborns and infants. Hence there is a need to conduct more studies for greater reliability and validity.

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