Tympanometry in Neonates- A Comparative Study

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Abstract

Objective: Impairment to hearing during childhood may lead to delay in the speech and language skills, making the communication process more difficult. Early identification and rehabilitation can benefit the children. It is necessary to test the hearing using accurate test procedures. Thus, aim of the study was to compare the use of probe tones (226Hz and 1000Hz probe tone) in tympanometry while testing the neonates for hearing before getting discharged from hospital setup.

Method: An inclusion - exclusion criteria was applied in selection of 60 neonates (1-17days). Hearing screening with comparison of 226Hz and 1000Hz probe tone in tympanometry was carried out using a comparative study design. Pressure ranging from + 200 to -400 daPa and a pressure change rate of 600/200 daPa per second was used for testing. Intensity of probe tone was adjusted at 85 dB SPL. Comparison was made for type of tympanogram, ear canal volume, compensated static peak acoustic admittance and tympanometric peak pressure. Sampled paired t test was used to carry out statistical analysis.

Results: 1000Hz probe tone surpassed the 226Hz probe tone in testing the neonates using tympanometry. A statistically significant difference was observed in all the sub-sections except similar values for ear canal volume.

Conclusion: Many changes occur in the ears of neonates like changes in bone density, mesenchymal loss which has an impact on the mechanical properties of the auditory canal and middle ear system. Thus, 1000Hz probe tone in tympanometry serves a promising tool.

Keywords: Probe tone; Neonates; Immittance audiometry

Abbreviations: DPOAE: Distortion Product Otoacoustic Emissions; SP: Single-peaked tympanogram; TPP: Tympanometric peak pressure; DP: Double-peaked tympanogram; IP: Inverted peaked tympanogram; A: Asymmetric tympanogram; F: Flat peaked tympanogram; Ymt: Compensated static peak acoustic admittance; ECV : Ear Canal volume

Introduction

Normal hearing ability is the main source for development of speech and language skills. Any impairment to hearing during childhood may lead to delay in the speech and language skills, making the communication process more difficult. However, early identification and rehabilitation if given can work for the benefit of the children. Therefore in neonates, it is recommended to carry out a complete hearing evaluation before moving out from the hospital setup post delivery. In addition, it is necessary to focus on the test battery used for testing the hearing of neonates. In accordance with the literature, there still persists a debate on using 226Hz probe tone and 1000Hz probe tone for testing the neonatal hearing.

Tympanometry is an umbrella term encompassing impedance, admittance, and their components. It is defined as mechanical analysis of the auditory system in response to acoustic stimulation. Acoustic immittance measures the acoustic energy transfer that occurs when sound pressure is applied to the tympanic membrane causing its movement. Thus it helps to evaluate the ease or opposition to this sound energy flow within the auditory system. Today, its contribution to clinical diagnosis has aided to better middle ear status diagnosis and has now become a routine part of the audiological test battery approach ranging towards neonates to geriatrics.

In the early years of life up to two years, normal ear tympanic-ossicular system acts differently as mass is the dominating physical feature of the ear. After this age, reaching the adult stage, there is a change in behavior which is controlled by stiffness and is better evaluated using probe frequency of 226 Hz [1]. Thus carrying out conventional tympanometry using 226Hz probe tone at early years of life may not serve of much help. Therefore, condition of the middle year in the early stages of life can be evaluated more expeditiously using high frequency probe tones such as 678 Hz and
A Term of Free and Informed Consent form was furnished to the Parents/caregivers which contained information about the study in very clear and uncomplicated language. Once the parental consent was signed and obtained the study was continued. The study incorporated 60 neonates: 21(35%) female and 39 (65%). The age ranged between from 1day to 17 days, with an average age of 2.9 days of life. Total of 120 years were evaluated right (100%) and left (100%).

Audiological interview was carried out to begin with the screening assessment, which was followed by visual inspection of the pinna and ear canal, Distortion Product Otoacoustic Emission testing and tympanometry measurements. Audiological interview in collaboration with information from hospital files was carried out with the parents/caregivers using leading questions, in simple and uncomplicated language. The purpose was to serve the information regarding neonatal hearing, presence of any upper respiratory tract infection, and high risk indicators for hearing impairment.

Visual inspection of the pinna, ear canal and tympanic membrane was carried out by an experienced clinical audiologist to rule out any disturbances in testing of tympanometry. If any disturbances were encountered the neonate was referred to the Oto-rhino-laryngologist for the further evaluation.

To acquire the tympanometry measurements, Interacoustics AT 235h impedance audiometer was used. Following the specifications of the equipment manual, tympanometry was applied using 226 Hz and 1000 Hz frequencies, with the pressure ranging from + 200 to -400 daPa and a pressure change rate of 600/200 daPa per second. The intensity of probe tone was adjusted at 85 dB SPL for 226 Hz and 1,000 Hz.

Two forty tympanograms were obtained: 114 (95%) with a 226 Hz probe tone, 109 (90.8%) with a 1,000 Hz probe tone. The occlusion encountered during the testing procedure lead to unequal distribution of the tympanograms. In the consequence of occlusion with a 226 Hz and 1000 Hz probe tone, the probe was removed from ear and repositioned to restart the testing.

The obtained Tympanogram shapes were categorized as either a single-peaked tympanogram (SP) with maximum tympanometric peak pressure (TPP), a double peaked tympanogram (DP) with two-peak TPP, an inverted peaked tympanogram (IP) with an inverted TPP, an asymmetric tympanogram (A) with a gradual decline of TPP ranging from +200 to -200 daPa and, or a flat peaked tympanogram (F) with no TPP. Similarly, compensated static peak acoustic admittance (Ymt) mentions the maximum peak admittance, where the pressures of the external and middle ear are equal. The maximum admittance peak pressure is expressed in daPa.

With the previous literature [10-12], using 226 Hz probe tone SP or DP tympanograms were classified as normal. For 1,000 Hz frequency, tympanograms were classified using the Sutton Protocol [13], used for infants up to the age of 4 months. Shadowing this protocol, tympanograms with Ymt>0 and TPP<-200 daPa were considered as normal. Tympanograms with Ymt<0 or TPP>+ 200 daPa were considered as abnormal. On classification of tympanograms as either normal or abnormal, the tympanograms with the two different probe tones were compared. In addition, to the literature, single-peaked and double-peaked tympanograms are considered normal, while asymmetric, inverted, and flat tympanograms are considered abnormal [13-16].

Results

Tympanometry was carried out in 60 healthy neonates using 226 Hz and 1000 Hz probe tone. The tympanometry measures were compared in accordance with type of tympanogram, ECV, Ymt, TPP. The obtained measures for 226 Hz and 1000 Hz were compared to know the efficacy of the probe tones. Sampled paired t test using SPSS version: 16 was used to obtain a statistically significant difference between the two probe tones.

On comparing the type of tympanograms, 226 Hz elicited 71 Single Peaked tympanogram with maximum tympanometric peak pressure and 49 flat peaked tympanogram (F) with no...
Using sampled paired t test it is evident that 1000Hz probe tone is more compatible for neonatal hearing testing then 226Hz probe tone with respect to ECV, Ymt and TPP. However there is a significant difference between the ECV and Ymt. Table 1 shows the statistical differences between the three parameters (Table 1).

**Table 1: Comparison between 226Hz and 1000Hz probe tone.**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>226Hz Probe Tone</th>
<th>1000Hz Probe Tone</th>
<th>T value</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECV</td>
<td>0.74cm³</td>
<td>0.71cm³</td>
<td>0.94</td>
<td>P&lt;0.05</td>
</tr>
<tr>
<td>Ymt</td>
<td>0.33cm³</td>
<td>0.45cm³</td>
<td>-3.56</td>
<td>P&lt;0.05</td>
</tr>
<tr>
<td>TPP</td>
<td>-31.33dapa</td>
<td>-12.07dapa</td>
<td>-3.08</td>
<td>P&lt;0.05</td>
</tr>
</tbody>
</table>

Using the 226Hz and 1000Hz probe tone, the ECV values were almost the same. There was less variation observed using 226Hz and 1000Hz probe tone frequencies. The sampled paired t test revealed no significant difference for the same. However, using 226Hz and 1000Hz probe tone Ymt and TPP were not the same. Sampled Paired t test revealed a significant difference between Ymt and TPP using 226Hz and 1000Hz probe tone in neonates.

A significant difference was observed, when the 226Hz and 1000Hz probe tone frequencies were compared. This indicates that the 1000Hz probe tone surpassed the limitations of 226Hz probe tone in the mass dominating middle ear system of the neonates with better measurements.

**Discussion**

The results were earned by grouping the right and left ears to facilitate better statistical analysis, as there was no significant difference found between the ears in the previous studies. In the present study a statistically significant difference across two subsections was seen.
differences are seen in the external ear and in the middle ear growth such as enlargement of the external ear, mastoid and middle ear cavity, changes in tympanic membrane orientation and tympanic annulus fusion. Some other variations such as changes in bone density and mesenchymal loss occurring during development could also play a major role. These changes could be related to the acoustic changes influencing the recording of the tympanogram with compensated static peak acoustic admittance [6, 16, 26, 27].

In addition, mass components are larger in high frequency and lower in the low frequency tympanometry [6, 22]. The normal middle ear is primarily dominated by the stiffness of low frequency sounds (226 Hz). In a higher frequency (for instance: 1000 Hz), the relative participation of each anatomical structure is changed and the acoustic admittance measured at the middle ear inlet becomes more predominated by the mass [12].

The admittance measurement in tympanometry indicates changes in the middle ear, literature reports higher mean Ymt values at 1,000 Hz compared to 226 Hz [11,13]. Mean Ymt values equal to 1.06 mmho when evaluating neonates [28]. The results of the current study are in acceptance with the literature. On statistical analysis 1000Hz probe tone obtained higher values of Ymt in comparison to 226Hz probe tone. Low frequency tympanometry in newborns and babies younger than six months has low sensitivity, in other words, the high level of false-negatives.

While comparing the tympanometric peak pressure (TPP) obtained with 226 Hz and 1000 Hz. The current study indicated a higher TPP value with 1000 Hz than with 226 Hz. Similar findings have been reported in the literature [3, 6]. Although there were statistically significant differences between the frequencies with respect to TPP, none of the differences were clinically significant. That is, the results for all 2 frequencies were within the normal range [13].

In addition, testing neonates using tympanometry, tympanograms with probe tone of 1000 Hz are reliable, easier to interpret than 226Hz probe tone. It is easy to interpret and more reliable (91%) using 1000Hz than the 226 Hz (35%) probe tone, which shows a significantly better result in the assessment of the middle ear system. Similarly, in infants younger than 3 months of age, 226 Hz probe tone resulted in 58% of false-positive results [25].

The results of the current study are in accordance with the findings in the literature. These findings provide evidence for further obtaining normative values at different ages to adapt clinical practice to the use of high frequency probe tones with young children.

Conclusion

The current study aimed at comparing the two probe tones and its measurements in tympanometry. The neonates were considered as the subjects of the study. The difficulties met by 226Hz probe tone were seen to be surpassed by 1000Hz probe tone in neonatal tympanometry acoustic measurements. Neonates can be well diagnosed using a 1000HZ probe tone using tympanometry. However, further is warranted as the sample size used in current is small.

Informed consent

Informed oral consent was obtained from all individual participants included in the study.

Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

References


