

SYMMETRY OF TYMPANOMETRIC MEASUREMENTS AND TRANSIENT EVOKED OTOACOUSTIC EMISSIONS IN NEONATES

Simetria das medidas timpanométricas e as respostas das emissões otoacústicas transientes em neonatos

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ABSTRACT

Purpose: to determine the occurrence of symmetry equal or greater than to 70% between ears comparing the results of 226 and 1000 Hz tympanograms to the otoacoustic emissions in neonates. **Methods:** participants were 39 neonates (20 female and 19 male) with 60 hours post birth on average. Each newborn underwent 226 and 1000 Hz probe tone tympanometry and transient evoked otoacoustic emissions in both ears. Data were submitted to statistical analysis. **Results:** an occurrence of symmetry <70% was observed for the otoacoustic emissions test in 74.4% of the neonates. The incidence of symmetry $\geq 70\%$ for the tympanometry for both probe tone of 226 and 1000Hz was 76.9% and 84.6 %, respectively. The comparison between gender and ear did not indicate a significant difference, although larger otoacoustic emissions amplitude was observed in the right ear. **Conclusion:** the results suggest a symmetry in the peripheral portion of auditory system, and the onset of asymmetries arising from the cochlea.

KEYWORDS: Otoacoustic Emissions, Spontaneous; Acoustic Impedance Tests; Infant, Newborn; Audiology

■ INTRODUCTION

Hearing impairment early in life can affect various aspects of child development, including linguistic, cognitive, psychosocial and academic aspects. For this reason, methods for the early evaluation of auditory system integrity are needed¹⁻⁴.

The recording of transient-evoked otoacoustic emissions (TEOAEs) is a method for evaluating the pre-neural function of the cochlea, especially the outer hair cells. Thus, this method is an excellent tool for detecting moderate to severe cochlear hearing loss⁵⁻⁸.

For TEOAE recording to be effective, it is important that the middle ear is in a suitable condition and that the external auditory canal does not contain residual amniotic fluid. The size of the external auditory canal is also an aspect to be considered, given that responses of greater amplitude are observed in neonates because the volume of the canal is small^{7,9-13}.

Acoustic immittance measurements are used to evaluate the general condition of the middle ear. They can be used to obtain a tympanogram, which is a record of the mobility of the tympanic-ossicular system in response to pressure variation, which allows abnormalities in the middle ear to be ruled out or confirmed¹⁴.

As such abnormalities may hinder the recording of TEOAEs, tympanogram analysis can be used as a complementary method for hearing evaluation¹⁵ because it enables the identification of middle ear impairment that can affect TEOAE results. For this

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reason, acoustic immittance assessment should always precede TEOAEs⁸.

The literature suggests that 226-Hz acoustic immittance measurements in neonates can provide normal tympanogram data even in infants with abnormalities in the outer and middle ear. It is therefore necessary to also apply a 1000-Hz probe tone to acquire more reliable results^{16,17}. Acoustic immittance using a 1000-Hz probe tone produces better results than using 226- and 678-Hz probe tones¹.

The relationship between the two tests described above notwithstanding, there is evidence in the literature that the auditory system works asymmetrically. In the central auditory nervous system, the left hemisphere is dominant for language skills. Regarding the peripheral auditory system, there is also evidence that TEOAE responses are stronger in the right ear^{7,18}. Given that middle ear conditions interfere with TEOAE responses and that an asymmetry in tympanometry could indicate a difference in this structure, the study of symmetry in tympanometric measurements, even within normal limits, will assist in understanding whether this fact is related to failures or differences in the otoacoustic emission records between the ears. This information will make it possible to understand whether differences between tympanograms can explain the differences observed in otoacoustic emission records.

This study aimed to analyze tympanometry measurements in newborns with 226- and 1000-Hz probe tones using the variables Tympanometric Peak Pressure (TPP), peak compensated admittance (Y_{tm}) and ear canal volume (ECV) along with TEOAEs to ascertain whether there is symmetry $\geq 70\%$ between the right and left ears for the TEOAE and tympanometry results.

METHODS

This work was a cross-sectional study conducted in the Human Hearing Investigation Laboratory, Faculty of Medicine, University of São Paulo (Faculdade de Medicina da Universidade de São Paulo – FMUSP). The research project was approved by the institution's Ethics Committee (CEP HU/USP 917/08).

The parents of the study's participants were informed of the research objectives and signed informed consent forms.

Case sample

Responses were collected for 39 neonates with ages between 24 and 78 hours (mean 60 hours). Of these subjects, 20 were females and 19 were

males, and the infants exhibited no risk factors for hearing loss according to the Joint Committee on Infant Hearing criteria¹⁹.

Equipment

The following equipment was used:

- Transient-evoked otoacoustic emissions module, included in the MEPA3 middle ear power analyzer (Mimosa Acoustics Inc., Champaign, Illinois, USA) with an ER-10C acoustic probe (Etymotic Research, Elk Grove Village, Illinois, USA) having two output and one input (microphone) transducers;
- MADSEN OTOFLEX 100 middle ear analyzer (GN Otometrics, Taastrup, Denmark) with output tympanometry for 226- and 1000-Hz probe tones for tympanometry research.

Procedures

Each infant was assessed for both ears. For tympanometry, a neonatal-sized rubber tip was introduced into the external auditory canal. After sealing the canal, the 226- and 1000-Hz tympanograms were obtained, with two measurements being taken in each ear for each probe tone to confirm the results. The 226-Hz tympanogram was obtained from the established baseline, excluding the equivalent volume of the external auditory canal. This measurement was obtained in milliliters (ml) in the tympanometric mode of compensated admittance at the height of the tympanic membrane (Y_{TM}). For the 1000-Hz probe tone, the tympanogram was obtained without external auditory canal volume compensation in the Acoustic Admittance mode (Y_a), and the unit of measurement was the millimho (mmho).

For the evaluation of TEOAEs, an ER-10C probe with a suitably sized rubber tip was inserted into the external auditory canal of the newborn, with a microphone and a miniature stimulus generator. Using this probe, an acoustic stimulus was emitted by the generator to stimulate the cochlear hair cells, which in turn emitted a response that was recorded by the microphone.

TEOAEs were considered present when the following results were obtained: reproducibility $\geq 50\%$, probe stability $\geq 70\%$ and signal to noise ratio responses greater than 3 dBNPS in the first two bands and 6 dBSPL in the last three bands.

Analysis of Results

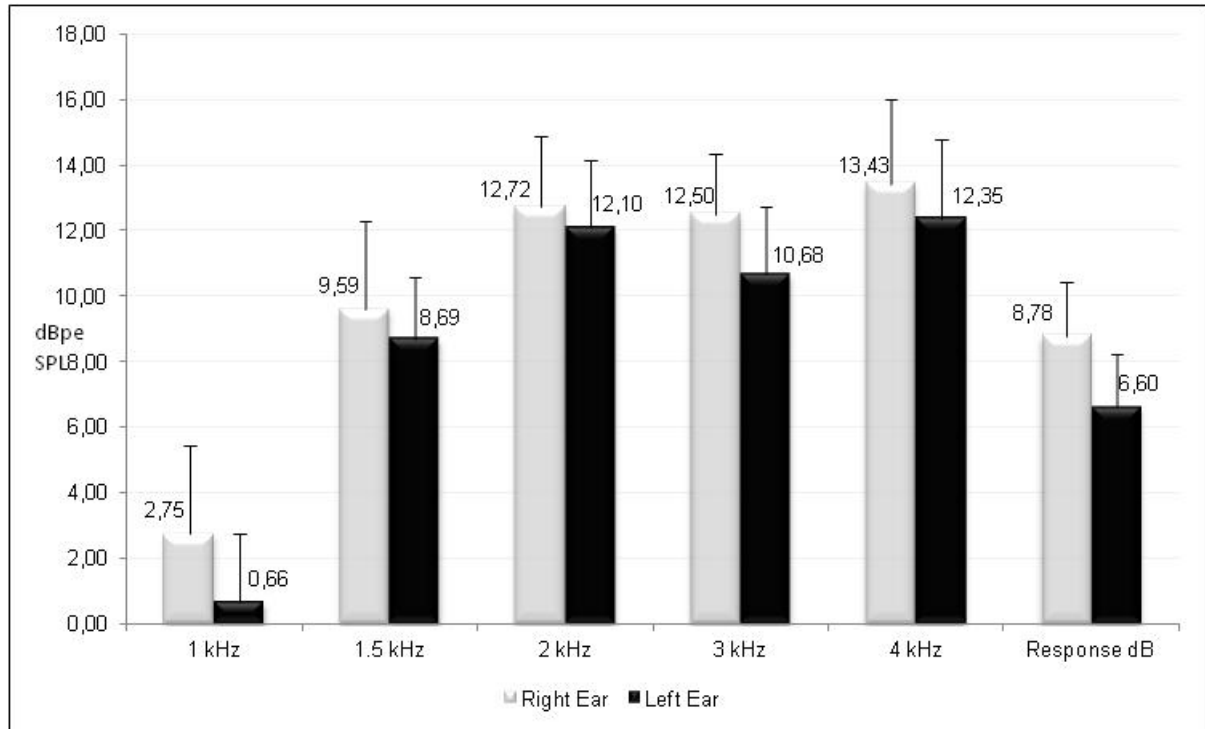
The results were analyzed by descriptive statistical tests to characterize the study population. Inferential analyses were performed using paired Student t-tests, ANOVA and tests for the Equality of Two Proportions. The agreement between the tests with respect to the symmetry of responses \geq

70% was also analyzed using the Kappa index. The significance level adopted was 0.05.

■ RESULTS

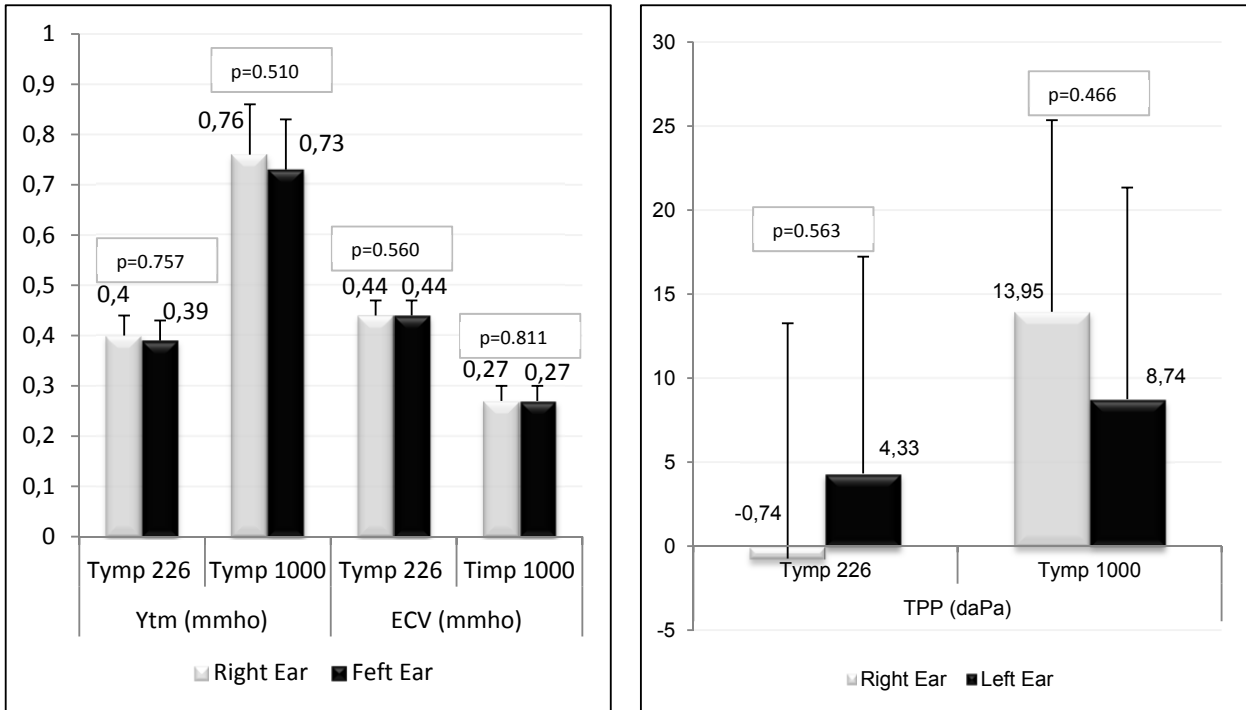
The TEOAE responses of the right and left ears were compared (Figure 1), as were the results of 226- and 1000-Hz tympanometry regarding the variables Tympanometric Peak Pressure (TPP),

peak compensated admittance (Y_{tm}) and ear canal volume (ECV) (Figure 2). The paired Student's t-test was used to analyze these measurements. Although the TEOAE response amplitude was higher in the right ears than in the left ears, the differences were not significant (Figure 1). There was a general trend for the right ear response to be greater than the left ear response. The differences observed for the tympanometry parameters were also not significant (Figure 2)



Legend: CI = confidence interval

Figure 1- Comparison of transient-evoked otoacoustic emissions between right and left ears (mean + CI).



The left panel shows comparison for the variables Ytm and ECV, and the right panel shows the results for TPP. Legend: CI = Confidence interval; TPP = tympanometric peak pressure; Ytm = admittance peak; ECV = ear canal volume

Figure 2- Comparison of tympanometry responses between right and left ears (mean and CI).

The test of Equality of Two Proportions was used to statistically compare the tympanogram curve type in the two studied frequencies (226 and 1000 Hz) and in the left and right ears. The results showed no difference regarding the ear, but there

was a difference between the types of probe used. The 226-Hz probe produced a Double Peak (DP) curve in 93.6% of cases, whereas the 1000-Hz probe produced a type A curve in 94.9% of cases (Figure 3).

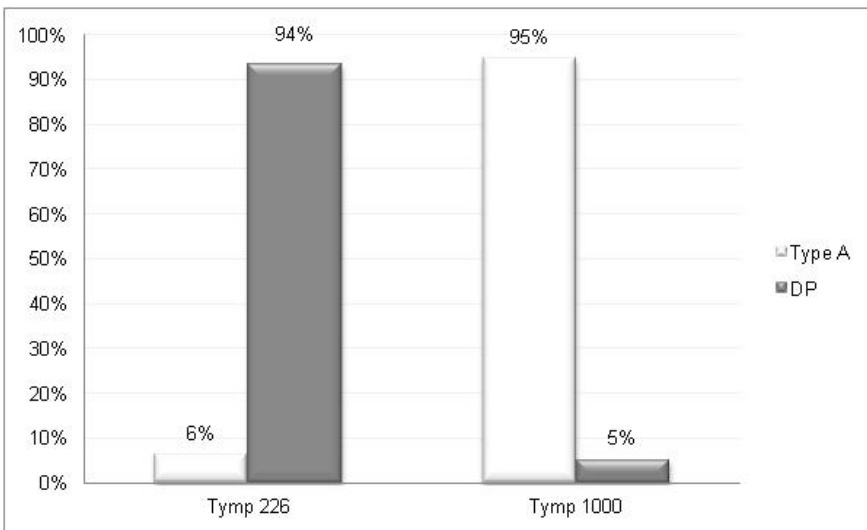


Figure 3- Occurrence of type A and double-peak (DP) tympanograms in neonates for the two studied probe frequencies.

The same measurements discussed above (TEOAE as well as TPP, Ytm and ECV for 226- and 1000-Hz tympanometry) were also compared with respect to gender using the ANOVA test.

The differences found in the comparison between genders for both the TEOAEs (Figure 4) and the tympanometry parameters were not significant (Table 1).

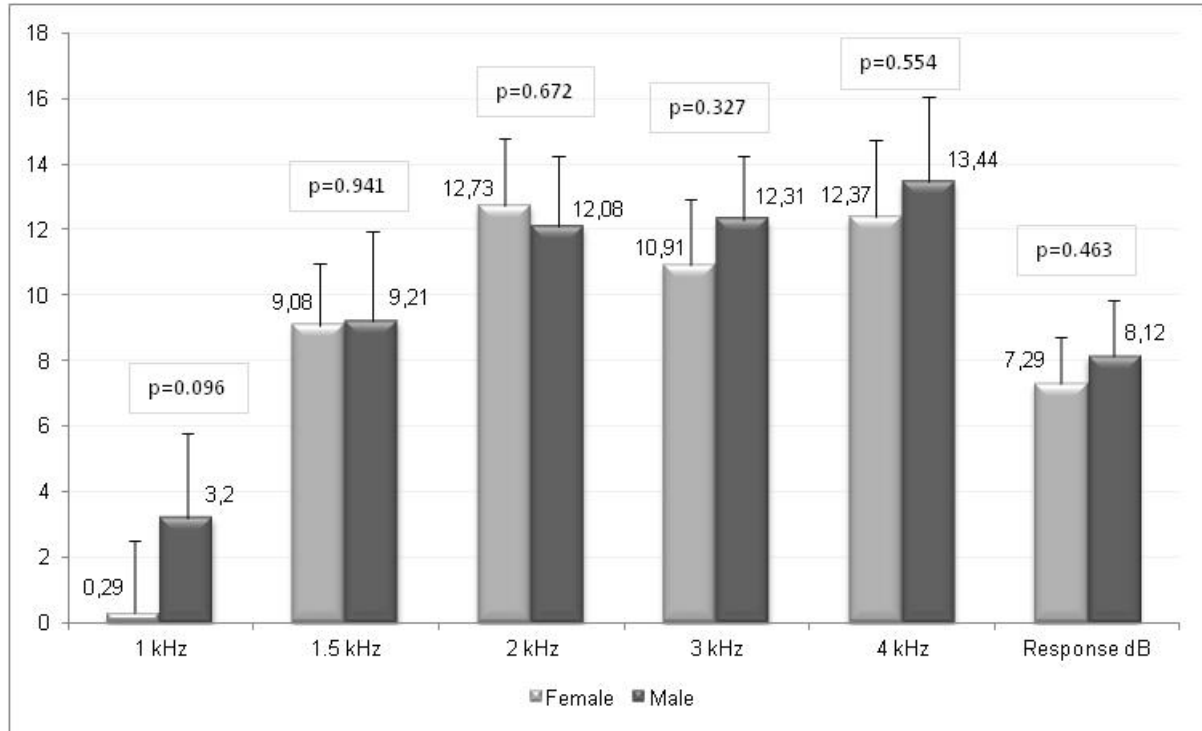


Figure 4 - Comparison of transient-evoked otoacoustic emissions according to gender

Table 1 – Difference between genders in the evaluation of transient-evoked otoacoustic emissions and tympanometry according to ANOVA statistical test

Test	p-value	
Tympanometry — 226 Hz	TPP	0.841
	Ytm	0.962
	ECV	0.458
Tympanometry — 1000 Hz	TPP	0.920
	Ytm	0.603
	ECV	0.432

Tympanometry showed a high occurrence of symmetry ($\geq 70\%$) between the ears at both 226 Hz and 1000 Hz. The TEOAE results, however, showed a higher occurrence of $< 70\%$ symmetry (Figure 5). The degree of agreement regarding the occurrence of symmetry between the tests was obtained using the Kappa index. The statistical analysis showed no correlation between these procedures, with the index for the 226 Hz probe being 2.5% (p-value 0.789) and the index for the 1000 Hz probe being -11.2% (p-value 0.137).

The test for the Equality of Two Proportions was used to compare the percentages of symmetry $\geq 70\%$ with the values below 70%. The three statistical tests with p-value < 0.001 showed significant differences, with tympanometry always showing a higher percentage of symmetry $\geq 70\%$, whereas TEOAE showed a higher occurrence of symmetry $< 70\%$. The p-value of the comparison among the three tests was < 0.001 .

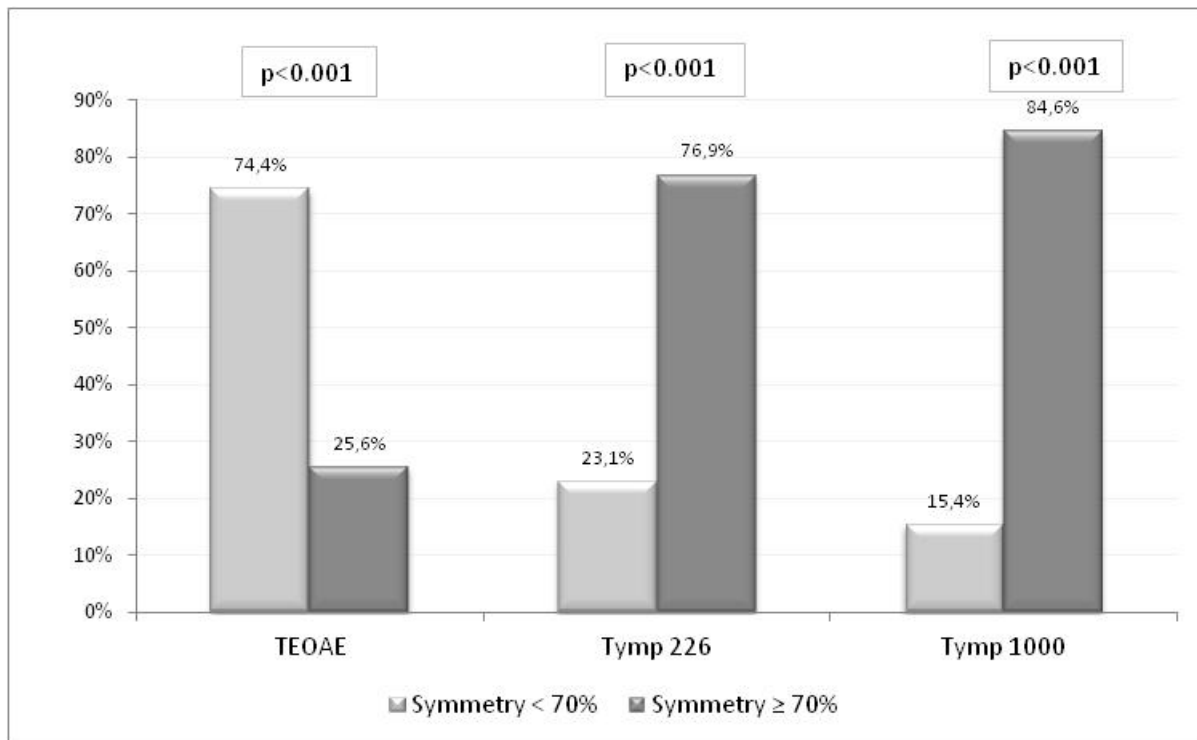


Figure 5 - Percentage of symmetry $\geq 70\%$ in measurements of transient-evoked otoacoustic emissions and 226- and 1000-Hz tympanometry

■ DISCUSSION

This study aimed to compare data obtained from the analysis of tympanometry and TEOAE responses for the variables gender and ear.

Initially, the TEOAE response levels from each ear were compared. Analysis of the symmetry pattern revealed a predominance of symmetry < 70% between the ears. There was a general trend for the right ear response to be greater. This “*advantage*” relative to the left ear has also been observed in other studies^{7,20}. It has been argued that the difference in TEOAE records between the ears is associated with the right ear having a slight advantage in aural sensitivity. This advantage could be a factor favoring left hemispheric dominance for language⁷, suggesting that the cochlear portion of the peripheral auditory system may also play an important role in the right ear advantage that is observed when evaluating the auditory processing of speech sounds.

Regarding the comparison of TEOAE responses between genders, the difference was also not significant. One previous study found higher levels of responses in females⁵. The present study had a small number of participants, which may have influenced the results. Studies with small numbers of participants usually do not show a significant difference between genders.

Regarding the tympanometric findings in this study, namely, the TPP, Ytm and ECV measurements for 226- and 1000-Hz tympanometry, no statistically significant difference was observed between ears or genders. Tympanometry revealed a pattern of symmetry ($\geq 70\%$) between the ears, which agrees with the findings described in the literature²¹. Regarding the type of tympanogram, we found a high incidence of DP curve at 226 Hz, representing 93.6% of responses, while at 1000 Hz, this type of curve was observed in only 5.1% of ears tested. This high percentage of DP curves at 226 Hz and of type A curves at 1000 Hz is in agreement with the findings in the literature¹. In a previous study that analyzed tympanometric measurements using 226-Hz probes, the authors found an equivalent number of single-peak curves - which are similar to the type A curve described in this study - and DP curves at 226 Hz, while at 1000 Hz, they found a higher incidence of single-peak curves. Regarding TPP, Ytm and ECV, a significant effect was observed on the ECV measurement for the 226-Hz probe tone and on the Ytm measurements at 1000 Hz, both of which were higher for males. In another study analyzing data from 1000-Hz tympanometry in neonates, the authors found type A curves in 92.2% of cases and DP curves in 1.2% of cases as well as statistically greater Ytm measurements for the right ear²². The data observed in these two studies

only agree with the present research in regard to the higher incidence of type A curves found at 1000 Hz. DP curves usually occur at the resonance frequency of the middle ear⁹. It is known that the resonance frequency in newborns is often lower than that in adults. Previous studies described resonance frequencies of 200 Hz in neonates, 380 Hz at three months and 1000 Hz in adults. The occurrence of DPs may be related to the resonance frequency of approximately 200 Hz in neonates²³.

Symmetry in tympanometry was observed based on the agreement between symmetry $\geq 70\%$ in the 226- and 1000-Hz tympanograms and the TEOAE responses in neonates. However, there was a higher occurrence of symmetry $< 70\%$ in the TEOAEs. These findings demonstrate that in

normal middle ear conditions, there is no influence of possible differences in tympanometry that could explain the differences in TEOAE records. The difference in TEOAE responses between the ears does not occur due to anatomical and physiological differences between the right and left middle ears but due to differences between the right and left cochlea.

■ CONCLUSION

Significant symmetry was observed only in tympanometry regardless of the probe used, suggesting that there is symmetry in the more peripheral portion of the auditory system and that asymmetries begin to occur from the cochlea.

RESUMO

Objetivo: verificar a ocorrência de simetria maior ou igual à 70%, entre as orelhas, comparando os resultados da timpanometria nas frequências de 226 e 1000Hz com as respostas das emissões otoacústicas em neonatos. **Métodos:** foram avaliados 39 neonatos, em média com 60 horas de vida, sendo 20 do sexo feminino e 19 do sexo masculino. Cada recém-nascido foi submetido à avaliação timpanométrica com as sondas de 226 e 1000 Hz, e avaliação das emissões otoacústicas transientes em ambas as orelhas. Os resultados foram submetidos a testes estatísticos. **Resultados:** na análise da amostra pode-se observar ocorrência de simetria $< 70\%$ nas respostas das emissões otoacústicas em 74,4% do total de neonatos. Por outro lado, na timpanometria, houve uma maior ocorrência de simetria $\geq 70\%$, tanto para sonda de 226 quanto para 1000Hz (76,9% e 84,6%, respectivamente). No que diz respeito ao gênero e orelha, as diferenças encontradas em cada teste não foram significantes, embora tenha sido observada maior amplitude de respostas de emissões otoacústicas na orelha direita. **Conclusão:** os resultados sugerem haver simetria no sistema auditivo em sua porção mais periférica, e início de assimetrias a partir da cóclea.

DESCRIPTORIOS: Emissões Otoacústicas Espontâneas; Testes de Impedância Acústica; Recém-Nascido; Audiologia

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