226 Hz and 1 kHz tympanometry in infants with risk indicators for hearing loss

Timpanometria com tons teste de 226 Hz e 1 kHz em um grupo de lactentes com indicadores de risco para deficiência auditiva

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ABSTRACT

Purpose: To analyze the results of 226 Hz and 1 kHz tympanometry in infants under six months of age, and to relate these results with age and with the results of Transient Evoked Otoacoustic Emissions (TOAE). **Methods:** The sample consisted of 142 infants with risk indicators for hearing loss, who had passed the Automated Auditory Brainstem Response (AABR) test. Subjects were submitted to 226 Hz and 1 kHz tympanometry and also to hearing screening with TOAE and AABR. Infants were divided into age groups (0-90 days old and 91-180 days old), and into groups 1 and 2, according to the presence or absence of TOAE, respectively. The tympanometric curves were classified into types A, Flat, C, Double Peak (DP), Asymmetrical (ASS) and Inverted (I), and also as normal or altered. **Results:** It was analyzed 245 ears. Type A tympanograms were predominant in both probe tones and in both groups. When tympanometric curves were analyzed according to age, it was verified that type A presented higher occurrence, followed by the type DP in infants younger than 90 days, and by the type Flat in infants older than 90 days. The 1 kHz tympanometry presented sensitivity of 74.01%, and specificity of 83.94%; the 226 Hz tympanometry presented sensitivity of 24.00% and specificity of 90.80%. **Conclusion:** The probe tone of 1 kHz had higher sensitivity to identify middle ear alterations, and therefore is the most appropriate to evaluate infants under six months of age.

Keywords: Hearing; Acoustic impedance tests; Middle ear; Infant; Spontaneous otoacoustic emissions

INTRODUCTION

Audiological diagnostic after hearing screening failure should be performed through a battery of tests appropriate to age and child development[1]. Tympanometry is part of this battery due to its objectivity and the fact that it allows the assessment of middle ear (ME) conditions, helping in the differential diagnosis between sensorineural or middle ear alterations.

Literature has shown that, in newborns and infants, tympanograms obtained with low frequency probe tones can be registered as normal, even in the presence of ME disease[2-6]. On the other hand, high frequency probe tones, especially 1 kHz, have higher sensitivity to identify these alterations and, therefore, should be used in neonates and infants under seven months of age[7-12].

Disagreements are also observed in literature regarding the age at which the high frequency tone test should be used. The Joint Committee on Infant Hearing (JCIH)[1] and the UK Newborn Hearing Screening Programme[13] recommend that, for infants under six months old, tympanometry is conducted using 1 kHz probe tone. This recommendation is also found in literature regarding infants under four[14] and five months[11] of age. Other authors[15], however, suggest 1 kHz probe tone for infants until three months old. As for infants between three and nine months old, according to the same study, middle ear assessment should be performed in two stages: first using the 1 kHz probe tone, and, in cases of failure in the results for this probe tone, tympanometry using 226 Hz tone. For infants over nine months old, the authors suggest the use of low frequency probe tone. These programs justify their use as a function of the resonance characteristics of infants' middle ear, and of some effects of the movement of

Study conducted at the Child Hearing Center, Division of Education and Rehabilitation of Communication Disorders, Pontifícia Universidade Católica de São Paulo – PUCSP – São Paulo (SP), Brasil, with a scholarship granted by Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES).
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Received: 12/26/2010; **Accepted:** 7/6/2011

the ear canal wall, which can be minimized by using high frequency probe tones.

Several researchers[16-23] have studied 226 Hz and 1 kHz tympanometry in neonates and infants, and have characterized the different types of tympanometric curves for these probe tones. They have also sought to establish correlations with the results obtained in the Otoacoustic Emissions (OAE) and the Brainstem Auditory Evoked Potential (BAEP), as well as to analyze the differences related to gender and ears.

Nonetheless, in the age range under six months old, the tympanometric curves found do not differentiate the presence or absence of middle ear alterations, that is, false positives and false negatives, in both frequencies of 226 Hz and 1 kHz, evidencing the need for better interpretation of them.

Thus, there is a need to study the influence of age and probe tone frequency used to obtain information regarding middle ear acoustic measurements and, hence, to provide more information on the use of these measures in clinical pediatrics. Moreover, it is used the cross check reasoning, that is, the use of more than one audiological procedure to define the hearing status and the auditory function, as in this study, which uses tympanometry associated with the record of otoacoustic emissions.

The purpose of this study was to analyze the results of tympanometry obtained with 226 Hz and 1 kHz probe tones in infants with risk indicators for hearing loss, and to relate them to the results obtained in OAE, analyzing the outcomes according to age group.

METHODS

This is a quantitative descriptive cross-sectional study. It was conducted from March 2008 to January 2009 in a high complexity hearing health referral service of the state of São Paulo, Brazil, covenant with the Unified Health System. The study was approved by the Research Ethics Committee of the *Pontifícia Universidade Católica de São Paulo* (PUC-SP), under protocol number 065/2007. Subjects' legal guardians signed a free and informed consent term, allowing their participation in the study and the dissemination of its results.

Participants were 142 infants, 72 male and 70 female, with ages between 12 and 180 days, and gestational age (GA) between 38 and 42 weeks. Birth weight ranged from 1,760 g and 4,363 g. Subjects were referred from maternity hospitals in the city of São Paulo, SP, Brazil, for outpatient hearing screening. All subjects presented risk indicators for hearing loss (RIHL) according to international criteria[1].

Screening procedures included Transient Otoacoustic Emissions (TOAE) at 73 dBpNPS intensity; and the Automated Auditory Brainstem Response (AABR) at 35 dBNA, using the automatic equipment AccuScreen, from GN Resound®.

All infants, included in the study for presenting RIHL, were submitted to the AABR test and showed present responses in both ears. However, in this study, only TOAE results were analyzed. Subjects were then divided into age groups – 0 to 90 days and 91 to 180 days – and also into group 1, comprising subjects with present TOAE, and group 2, subjects with absent TOAE.

Tympanometry was carried out using the middle ear analyzer AT 235h, from Interacoustics®, characterized as an automatic equipment with graphic print, using probe tones of 226 Hz and 1 kHz. Pressure ranged from +200 daPa to -400 daPa, with 50 daPa/second speed and 85 dBNPS intensity, for both probe tones. All tests were conducted with the child in the mother's or caregiver's lap while in natural sleep or, when this was not possible, in peaceful state with no moving.

Infants were assessed using the 226 Hz probe tone, followed by the 1 kHz probe tone. The first ear assessed was not pre-defined, hence the choice was based on the position of the infant in the mother's or caregiver's lap at the beginning of the exam. Were excluded ears from which the tympanometric curve could not be obtained due to exhaust pressure. Therefore, some children did not have both ears analyzed.

According to previous studies[24-26], tympanometric curves were classified into types A, Flat, C, and DP (Double Peak), as well as into normal (type A) or altered (types C and Flat), using a 226 Hz probe tone; and into types A, Flat, C, DP, Asymmetrical (ASS) and Inverted (I), as well as into normal (type A) or altered (C and Flat types), using a 1 kHz probe tone. For the classification into normal or altered, curve types DP, ASS and I were excluded because there is still controversies in literature regarding normal standards[11,15,17,20,21,23].

In data analysis the types of tympanometric curves obtained with both probe tones were described and related to TOAE results based on statistical tests, in order to verify the specificity and sensitivity of these tones.

RESULTS

In this study, 142 children were evaluated, 70 (49.3%) female and 72 (50.7%) male, with ages between 12 and 180 days. However, only 245 ears were analyzed (123 right ears and 122 left ears).

No differences were observed between ears regarding tympanometric types, hence, data were analyzed altogether.

Types of tympanometric curves

The records of 245 tympanograms were analyzed, and six types of tympanometric curves were observed: A, ASS, C, DP, I, Flat.

The analysis of the types of tympanometric curves according to age (Table 1) showed that type A had higher percentage

Table 1. Occurrences and percentages of the different types of curve at 226 Hz, by age group – right and left ears

Age range (days)		Curve type				Total
		A	C	DP	Flat	
≤90	n	122	4	74	12	212
	%	57.55	1.89	34.91	5.66	100
>90	n	27	0	2	4	33
	%	81.82	0	6.06	12.12	100
Total	n	149	4	76	16	245
	%	60.82	1.63	31.02	6.53	100

Note: A = type A curve; C = type C curve; DP = double peak curve

of occurrence than the other types in both age groups; however, the proportion of type A in the age group ≤90 days was lower than in the group >90 days. It was also verified that the type DP had higher occurrence in the younger group, while type C was the less frequent in both age groups.

Table 2 shows that type A curve predominated in both age groups for both ears. Types ASS, Flat and I had higher percentage of occurrence in infants older than 90 days, and types DP and C, in subjects younger than 90 days.

For 226 Hz, type A tympanogram was predominant, followed by type DP. Similarly, for the higher frequency probe tone, there was a predominance of type A curve, followed, however, by Flat curve.

Table 3 presents the distribution of different tympanometric curves, showing the agreement between the results in the two probe tones used. When the probe tones of 226 Hz and 1 kHz are associated to the same infant, it is possible to observe the tympanometric curves found in each situation.

Types of tympanometric curves according to TOAE results

We evaluated 245 ears using the TOAE protocol, 211 with present responses and 34 with absent responses. Table 4 shows the association between the types of tympanometric curves and the results obtained in TOAE for both groups.

When the types of curves obtained using the 226 Hz tone were analyzed according to the TOAE results, the type A curve was predominant in both groups for both ears, and the type DP presented higher percentage in group 1. Oppositely, with 1 kHz the type A curve predominated in group 1, and the type Flat was more frequent in group 2.

Table 5 presents the occurrences and percentages of the results for the type of curve, normal or altered, and the relationship with TOAE results, that is, in groups 1 and 2. It was found that, at 226 Hz, normal results were predominant in both groups, while at 1 kHz normal results predominated in group 1.

We also analyzed which probe tone was closer to the TOAE results, as shown in Chart 1. To this end, the Cohen's Kappa coefficient was calculated[27]. In the situation of perfect agreement, the Kappa equals one. It is observed that the average agreement value for the right ear at 226 Hz is considerably lower than the same value at 1 kHz. When the limits of the confidence intervals for 226 Hz and 1 kHz are compared, it is noted a small intersection, indicating that the agreement is higher for 1 kHz.

Sensitivity, specificity, and proportions of false positives and false negatives for 226 Hz and 1 kHz curves are presented in Chart 2. Due to the impossibility to use medical otoscopy to evidence middle ear alterations in the children evaluated in this study, the present or absent result in the otoacoustic

Tabela 2. Ocorrências e porcentagens dos diferentes tipos de curva em 1 kHz, por faixa etária – orelhas direita e esquerda

Age range (days)		Curve type						Total
		A	ASS	C	DP	I	Flat	
≤90	n	154	11	16	4	2	25	212
	%	72.64	5.19	7.55	1.89	0.94	11.79	100
>90	n	15	6	1	0	3	8	33
	%	45.45	18.18	3.03	0	9.09	24.24	100
Total	n	169	17	17	4	5	33	245
	%	68.98	6.94	6.94	1.63	2.04	13.47	100

Note: A = type A curve; ASS = asymmetrical curve; C = type C curve; DP = double peak curve; I = inverted curve

Table 3. Distribution, occurrence and percentage of the types of curves for both probe tones, and association of the type of curve at 1 kHz for each category of curve at 226 Hz – right and left ears

226 Hz		1 kHz						Total
		A	ASS	C	DP	I	Flat	
A	n	103	13	7	3	5	18	149
	%	69.13	8.72	4.70	2.01	3.36	12.08	100
C	n	1	0	3	0	0	0	4
	%	25	0	75	0	0	0	100
DP	n	60	3	6	1	0	6	76
	%	78.95	3.95	7.89	1.32	0	7.89	100
Flat	n	5	1	1	0	0	9	16
	%	31.25	6.25	6.25	0	0	56.25	100
Total	n	169	17	17	4	5	33	245
	%	68.98	6.94	6.94	1.63	2.04	13.47	100

Note: A = type A curve; ASS = asymmetrical curve; C = type C curve; DP = double peak curve; I = inverted curve

Table 4. Occurrences and percentages of the different types of curves in group 1 (present TOAE) and in group 2 (absent TOAE) obtained with 226 Hz and 1 kHz probe tones – right and left ears

EOAT		Curve types												Total	
		A		C		DP		Flat		ASS		I			
		226 Hz	1 kHz	226 Hz	1 kHz	226 Hz	1 kHz	226 Hz	1 kHz	226 Hz	1 kHz	226 Hz	1 kHz	226 Hz	1 kHz
Group 1	n	130	162	2	11	67	4	12	20	-	12	-	2	211	211
	%	61.61	76.78	0.95	5.21	31.75	1.90	5.69	9.48	-	5.69	-	0.95	100	100
Group 2	n	19	7	2	6	9	0	4	13	-	5	-	3	34	34
	%	55.88	20.59	5.88	17.65	26.47	0	11.76	38.24	-	14.71	-	8.82	100	100
Total	n	149	169	4	17	76	4	16	33	-	17	-	5	245	245
	%	60.82	68.98	1.63	6.94	31.02	1.63	6.53	13.47	-	6.94	-	2.04	100	100

Note: TOAE = Transient Otoacoustic Emissions; A = type A curve; ASS = asymmetrical curve; C = type C curve; DP = double peak curve; I = inverted curve; Group 1 = present TOAE; Group 2 = absent TOAE
PS.: Curve types ASS and I were not found at 226 Hz

Table 5. Occurrences and percentages of the results regarding types of curves found in groups 1 and 2 at 226 Hz and 1 kHz – right and left ears

TOAE		226 Hz			1 kHz		
		Curve		Total	Curve		Total
		Altered	Normal		Altered	Normal	
Group 1	n	14	130	144	31	162	193
	%	9.72	90.28	100	16.06	83.94	100
Group 2	n	6	19	25	20	7	27
	%	24.00	76.00	100	74.07	25.93	100
Total	n	20	149	169	51	169	220
	%	11.83	86.17	100	23.18	76.82	100

Note: TOAE = Transient Otoacoustic Emissions; Group 1 = present TOAE; Group 2 = absent TOAE
PS.: 226 Hz and 1 kHz tympanometry: normal (type A) and altered (types C and Flat)

Chart 1. Agreement measures for comparison between curves obtained at 226 Hz and 1 kHz

Ear	Probe tone	Kappa	Lower limit	Upper limit
RE	226 Hz	0.083	-0.123	0.290
	1 kHz	0.445	0.271	0.619
LE	226 Hz	0.218	0.002	0.435
	1 kHz	0.396	0.223	0.568
RE+LE	226 Hz	0.156	0.006	0.305
	1 kHz	0.420	0.297	0.543

Note: RE = right ear; OE = left ear

emissions was used as parameter to confirm these alterations, as already used in previous studies[21].

It can be observed that the sensitivity is greater when the 1 kHz probe tone is used. With regards to specificity, when the 226 Hz probe tone is used, the values are slightly higher. On the other hand, the "false positive" and "false negative" results were less frequent at 1 kHz.

DISCUSSION

Tympanometry provides important information regarding the conditions of the middle ear, and helps the diagnosis of temporary conducive hearing loss due to middle ear alterations[7,8].

When the age range of subjects is analyzed using the 226

Chart 2. Measures of sensitivity, specificity, false positive and false negative, calculated for each ear in relation to the probe tones of 226 Hz e 1 kHz

Probe tone	RE		LE		RE+LE	
	226 Hz	1 kHz	226 Hz	1 kHz	226 Hz	1 kHz
Sensitivity (%)	16.67	80.00	30.77	70.59	24.00	74.07
Specificity (%)	90.79	86.46	89.71	81.44	90.28	83.94
False positive (%)	77.78	61.90	63.64	60.00	70.00	60.78
False negative (%)	12.66	2.35	12.86	5.95	12.75	4.14

Note: RE = right ear; OE = left ear

Hz tone, it is observed that the percentage of curves types A and Flat increased with age, while the type DP decreased. In a previous study[15], the percentage of type A curves also increased with age, while the DP curves decreased. In adulthood, 100% of the tympanograms presented type A curve, and the DP curve was not observed in children older than nine months. However, unlike the present study, Flat curve occurred in high proportions in both age groups.

It was found that for 1 kHz probe tone, curve types A, C and DP decreased with age. In a previous study[16] it was also observed a decrease in the number of type DP tympanograms with age. However, other authors[15], in contrast, have observed an increase in the number of type DP curves. The differences from the present study could be explained by the fact that the sample of the previous study did not include children with suspicion of middle ear disease, which may have influenced the type of curve in the different age groups in the current study.

All infants assessed in this study, passed the hearing screening performed with AABR. Under these conditions, considering a screening protocol that uses both TOAE and AABR, the absence of TOAE responses is a strong indication of possible external or middle ear alteration. Thus, it was possible to relate the types of tympanometric curves with the TOAE results, and also to analyze the sensitivity of low and high frequency probe tones to infer possible middle ear diseases.

The analysis of the types of tympanometric curves obtained with probe tone of 226 Hz, regardless of the outcome on the TOAE, allowed noting that the type A curve predominated over the others, followed by the DP type. On the other hand, Flat and C curves had lower incidence.

The results observed regarding the frequency of occurrence of the different types of tympanometric curves were similar to those obtained in another study with infants between 13 and 248 days, which also showed predominance of type A curves (89.69%), and fewer DP curves (10.31%)[17]. In a previous study[21] with younger infants, whose ages varied from six to 30 days, a balance was observed between curve types A and DP. These differences are probably due to ear canal size and the ears resonance characteristics for different age groups.

For the 1 kHz probe tone, it was also possible to verify that the type A curve predominated over the other types. The second highest occurrence was the Flat curve, followed by types ASS and C and, less frequently, types DP and I.

Similar results were found in another study[17], which found a percentage of 85.72% for type A curves. However, unlike the present study, DP curves were found in 2.6% of the subjects studied, ASS in 5.19%, I in 5.19%, and Flat in 1.3% of the children. These results also agree with those of other researchers[20], who found type A curves in 92.2%, Flat curves in 5.7%, DP in 1.2%, and other atypical curves in 0.8% of the ears. High incidence of type A curves (70.9%), followed by ASS (28.2%) and I curves (0.9%), was also found in a study with infants up to 30 days[21].

In group 1, the types of curves obtained with probe tone of 226 Hz, related to the TOAE results, resemble the results of other studies[17,22] which also showed type A tympanometric curves in most ears with present TOAE responses. Other researchers[20,21] found higher frequency of curve types A and DP in patients with present OAE.

In group 2, with absent TOAE responses, most children presented type A curve, followed by Flat, corroborating the results of a previous study[22], which also found a higher percentage of type A curve (48.5%), however with Flat curves (33.3%) in higher percentage than the present study.

With probe tone of 1 kHz, in the group of children with present TOAE, type A curve was present in higher number. Similar previous studies[17,20] also found type A curves in most of the ears assessed. Another study with infants[22] obtained high percentage of type A curve, followed by ASS, but did not find records of DP and Flat curves.

Thus, it is known that the mobility of the ear canal and the equivalent volume of the middle ear can influence the results of tympanometry, based on the resonance generated by the tones used. This influence is less important when a 1 kHz tone is used, allowing better admittance measures[5]. In addition, new studies are being conducted in search of new technologies that will enable more accurate interpretation of the findings obtained in the assessment of the middle ear and its alterations, as it is the case of the acoustic reflectance measurement.

In the ears with absent TOAE, the present study found a higher number of Flat curves than type A curves. An international research[11] also found Flat curves in most of the tested ears; however, unlike this study, none of the subjects in the group of children with middle ear alteration presented normal curve.

The explanation for the occurrence of various tympanometric types with present OAE and supposedly normal ME function is unclear. This may be due to factors such as normal variation within population, or mild ME dysfunction that does not hinder the registration of OAE. It is also possible that the frequency of the tone test used was not high enough for some newborns[20].

This author also notes that there may have been inadequate probe sealing or child movements, producing artifacts during the test. This explanation does not apply to the present study, since only the tympanometric curves satisfactorily obtained were analyzed, that is, curves obtained with no child movements, no exhaust pressure during the test, and with a clear and well defined outline. Finally, the author emphasizes that there is not always a direct correspondence between ME conditions and the tympanometric type[20].

Considering the classification of the tympanometric curves in normal or altered with the 226 Hz probe tone, this study showed predominance of normal results, regardless the TOAE outcome. In the group with present TOAE, most ears were considered normal, as well as in the group with absent TOAE, and only a few were considered altered. These results show that the 226 Hz tone presented little sensitivity to identify ME alterations.

For the 1 kHz probe tone, in the group with present TOAE most of the ears were considered normal, and in the group with absent TOAE most tympanometric curves were altered. That is, the tympanometric curves were better discriminated when the 1 kHz tone was used, showing greater sensitivity to detect ME alterations.

The analyses of sensitivity, specificity and proportion of false positives and false negatives at 226 Hz and 1 kHz, in

relation to TOAE results, showed that the 1 kHz probe tone had higher sensitivity, corroborating previous studies[11,18] that also found that the use of 226 Hz probe tone has low sensitivity for the assessment of infants, since normal tympanograms were registered even in the presence of ME alterations. These studies concluded that the high frequency probe tone has greater sensitivity to detect ME alterations in neonates and infants, and should, therefore, be the frequency of choice for this population.

Regarding the specificity with the 226 Hz probe tone, the values were slightly higher; however, the false positives and false negatives were less frequent with 1 kHz. These results are similar to those of other authors[19] who observed, in the presence of TOAE and Distortion Product Otoacoustic Emissions (DPOAE), altered results in the 226 Hz tympanometry, suggesting that this tone produces a high rate of false positive results in the detection of ME alterations. The 1 kHz tone, in contrast, showed altered results in the absence of TOAE and DPOAE, indicating a low rate of false positives. Another study[23] observed that, in infants with present TOAE, both tones had good specificity; however, for infants with absent TOAE, the 1 kHz probe tone was more sensitive to identify possible ME alterations.

Within an audiological diagnostic service, the specificity and sensitivity of the tests used are crucial to ensure all aspects related to the quality of the program developed.

Since in the present study all infants had present responses in the AABR, the fails in the TOAE may be related to the occurrence of ME alterations, which are very common in this population; therefore the specificity and sensitivity of the tympanometry using 226 kHz and 1 kHz probe tones could be evaluated.

Like other studies, this research has shown limitations in the use of tympanometry for the age range under six months, both for 226 Hz and 1 kHz probe tones. Even though the 1 kHz probe tone has shown more accurate results, currently studies using acoustic reflectance must be emphasized, so that we can investigate whether this new procedure can be used in child audiology practice, as part of the battery of tests needed.

CONCLUSION

Based on the results obtained in this research, it can be conclude that there was a higher occurrence of type A curves compared to other curves for both probe tones (226 Hz and 1 kHz). The 1 kHz probe tone showed higher sensitivity to correctly detect abnormal tympanometric curves, while the 226 Hz probe tone presented higher specificity. With regards to age range, it can be conclude that the results for conventional tympanometry using a 226 Hz probe tone get better with age.

Both probe tones presented false positives and false negatives results, however these are less frequent with 1 kHz, and therefore this is the most appropriate tone to assess newborns and infants under six months old.

ACKNOWLEDGEMENTS

We thank the *Coordenação de Aperfeiçoamento de Pessoal de Nível Superior* (CAPES) for the scholarship granted, the Child Hearing Center (CeAC – *Centro Audição na Criança*), the Division of Education and Rehabilitation of Communication Disorders (DERDIC – *Divisão de Educação e Reabilitação dos Distúrbios da Comunicação*), all the parents who allowed participation of their children in this study and the students and staff from CeAC, DERDIC and PUC-SP for all the support and encouragement.

RESUMO

Objetivo: Analisar os resultados da timpanometria com tom teste de 226 Hz e 1 kHz em lactentes até seis meses de idade e relacionar com a faixa etária e com os resultados das Emissões Otoacústicas por Estímulo Transiente (EOAT). **Métodos:** A amostra consistiu de 142 lactentes com indicadores de risco para deficiência auditiva que passaram no Potencial Evocado Auditivo de Tronco Encefálico – Automático (PEATE-A). Estes foram submetidos à timpanometria com tom teste de 226 Hz e 1 kHz e à triagem auditiva por meio das EOAT e do PEATE-A. Os lactentes foram divididos por faixa etária (de 0-90 dias e 91-180 dias) e em grupos 1 e 2, segundo presença ou ausência de EOAT, respectivamente. As curvas timpanométricas foram classificadas em tipos A, Plana, C, Duplo Pico (DP), Assimétrica (ASS) e Invertida (I), e como normal ou alterada. **Resultados:** Foram analisadas 245 orelhas. A curva do tipo A foi predominante nos dois tons testes e nos dois grupos. Ao analisar os tipos de curva, de acordo com a idade, verificou-se que o tipo A apresentou maior ocorrência, seguida do tipo DP nos lactentes menores de 90 dias e da Plana, nos maiores de 90 dias. O tom de 1 kHz apresentou 74,01% de sensibilidade e 83,94% de especificidade; já o de 226 Hz, 24,00% de sensibilidade e 90,80 % de especificidade. **Conclusão:** O tom teste de 1 kHz foi o mais sensível para identificar alterações de orelha média e, portanto, o mais adequado para avaliar lactentes até os seis meses de idade.

Descritores: Audição; Testes de impedância acústica; Orelha média; Lactente; Emissões otoacústicas espontâneas

REFERENCES

1. American Academy of Pediatrics, Joint Committee on Infant Hearing. Year 2007 position statement: Principles and guidelines for early hearing detection and intervention programs. Pediatrics. 2007;120(4):898-921.
2. Paradise JL, Smith CG, Bluestone CD. Tympanometric detection of middle ear effusion in infants and young children. Pediatrics. 1976;58(2):198-210.
3. Marchant CD, McMillan PM, Shurin PA Johnson CE, Turczyk VA, Feinstein JC, et al. Objective diagnosis of otitis media in early infancy by tympanometry and ipsilateral acoustic reflex thresholds. J Pediatr. 1986;109(4):590-5.
4. Hunter LL, Margolis RH. Multifrequency tympanometry: current clinical application. Am J Audiol. 1992;1(3):33-43.
5. Keefe DH, Levi E. Maturation of the middle and external ears: acoustic power-based responses and reflectance tympanometry. Ear Hear. 1996;17(5):361-73.
6. McKinley AM, Grose JH, Roush J. Multifrequency tympanometry and evoked otoacoustic emissions in neonates during the first 24 hours of life. J Am Acad Audiol. 1997;8(3):218-23.
7. Margolis RH, Hunter LL. Timpanometria: princípios básicos e aplicações clínicas. In: Musiek FE, Rintelmann WI, editores. Perspectivas atuais em avaliação auditiva. São Paulo: Manole; 2001. p. 85-126.
8. Margolis RH, Bass-Ringdahl S, Hanks WD, Holte L, Zapala DA. Tympanometry in newborn infants- 1kHz norms. J Am Acad Audiol. 2003;14(7):383-92.
9. Sininger YS. Audiologic assessment in infants. Curr Opin Otolaryngol Head Neck Surg. 2003;11(5):378-82.
10. Shahnaz N, Miranda T, Polka L. Multifrequency tympanometry in neonatal intensive care unit and well babies. J Am Acad Audiol. 2008;19(5):392-418.
11. Baldwin M. Choise of probe tone and classification of trace patterns in timpanometry undertaken in early infancy. Int J Audiol. 2006;45(7):417-27.
12. Swanepoel de W, Werner S, Hugo R, Louw B, Owen R, Swanepoel A. High frequency immittance for neonates: a normative study. Acta Otolaryngol. 2007;127(1):49-56.
13. Baldwin M, editor. Neonatal Hearing Screening and Assessment. Timpanometry in babies under 6 months. A Recommended Test Protocol. Version 2.0 [Internet] 2008 [cited 2009 Ago 201]]. Available from: http://hearing.screening.nhs.uk/audiologyprotocols#fileid10753.
14. Holte L, Margolis RH, Cavanaugh RM Jr. Developmental changes in multifrequency tympanograms. Audiology. 1991;30(1):1-24.
15. Alaerts J, Luts H, Wouters J. Evaluation of middle ear function in young children: clinical guidelines for the use of 226 and 1000Hz tympanometry. Otol Neurotol. 2007;28(6):727-32.
16. Vincent VL, Gerber SE. Early development of the acoustic reflex. Audiology. 1987;26(6):356-62.
17. Carvallo RM. Medida de imitância acústica em crianças de zero a oito meses de idade [tese]. São Paulo: Universidade Federal de São Paulo, Escola Paulista de Medicina; 1992.
18. Meyer SE, Jardine CA, Deverson W. Developmental changes in tympanometry: a case study. Br J Audiol. 1997,31(3):189-95.
19. Rhodes MC, Margolis RH, Hirsch JE, Napp AP. Hearing screening in the newborn intensive care nursery: comparison of methods. Otolaryngol Head Neck Surg. 1999;120(6):799-808.
20. Kei J, Allison-Levick J, Dockray J, Harrys R, Kirkegard C, Wong J, et al. High-frequency (1000Hz) tympanometry in normal neonates. J Am Acad Audiol. 2003;14(1):20-8.
21. Silva KA, Novaes BA, Lewis DR, Carvallo RM. Achados timpanométricos em neonatos com emissões otoacústicas presentes: medidas e interpretações. Rev Bras Otorrinolaringol. 2007;73(5),633-9.
22. Linares AE, Carvallo RM. Medidas imitanciométricas em crianças com ausência de emissões otoacústicas. Rev Bras de Otorrinolaringol. 2008;74(3):410-6.
23. Garcia MV, Azevedo MF, Testa JR. Medidas de imitância acústica em lactentes com 226 Hz e 1000 Hz: correlação com as emissões otoacústicas e o exame otoscópico. Rev Bras Otorrinolaringol. 2009;75(1):80-9.
24. Jerger J. Clinical experience with impedance audiometry. Arch Otolaryngol. 1970;92(4):311-24.
25. Lidén G. The scope and application of current audiometric tests. J Laryngol Otol. 1969; 83(6):507-20.
26. Margolis RH; Smith P. Tympanometry in infants: state of art. In: Harford E, Klein J, editors. Impedance screening of middle ear disease in children. New York: Grune and Stratton; 1978.
27. Fleiss JL. Statistical methods for rates and proportions. New York: Wiley; 1973.