Características das emissões otoacústicas por transientes em programa de triagem auditiva neonatal*****

Characteristics of transient evoked otoacoustic emissions in newborn hearing screening program

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Abstract
Background: otoacoustic emissions (OAE) are considered the main instrument of the Newborn Hearing Screening Program (NHSP). Aim: to analyze the OAE of newborns evaluated in the NHSP. Method: transient evoked OAE recordings were captured in 1000 infants. The data were analyzed using the analysis of multivaried variance (Manova). Results: reference tables were calculated for the over all OAE levels and for frequency bands, according to gender and ear. The duration of the exam in the nursery was shorter than in the clinic. Conclusion: The level of the OAE was influenced by gender and ear, except for 0,7kHz. However, there were no observed differences between neonates without and with auditory risk.
Key Words: Infant; Risk Factors; Otoacoustic Emissions; Spontaneous.

Resumo
Tema: as emissões otoacústicas (EOA) são consideradas como o principal método dos programas de triagem auditiva neonatal (PTAN). Objetivo: analisar as EOA de neonatos avaliados em PTAN. Método: foi realizada captação das EOA por transiente em 1000 lactentes. Os dados foram analisados por modelo de análise de variância multivariada (Manova). Resultados: foram calculadas tabelas de referência para os níveis das EOA geral e por banda de freqüência, segundo o gênero e a orelha. A duração do exame na maternidade foi menor do que no ambulatório. Conclusão: o nível das EOA foi influenciado pelo gênero e orelha, exceto para 0,7kHz, porém não foi observada diferença entre as respostas dos neonatos sem e com risco auditivo.
Palavras-Chave: Lactente; Fatores de Risco; Emissões Otoacústicas Espontâneas.

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Introduction

One of the most fascinating audiology discoveries, in the last years, certainly was the understanding of the cochlea active mechanisms (Davis,1983).

The otoacoustic emissions (OAE) reflect the active and micromechanical proprieties of the organ of Corti (Kemp,2002), and the outer hair cells (OHC) seem to be particularly involved in their generation (Dallos; He, 2000). The transient evoked otoacoustic emissions (TEOAE), one way to evoke OAE, recording occurs when the ear is stimulated with a very short but strong broadband stimulus (click). The procedure is non-invasive, quick, applicable in a non-soundproof area, objective (it doesn't depend of individual response), and with a level of sensitivity from mild to profound hearing loss, uni or bilateral.

The OAE presence indicate that the preneural cochlear receptor mechanism (and necessarily the middle ear mechanism as well) is able to respond to sound in a normal way, indicating healthy cochlear status. The discovery of OAE and of the proper technique to register the signals fit the need of testing a great number of neonates.

According to national and international organizations about infant hearing (JCIH,2000; CBPAI,2001) 30 to 50% of child with significant hearing loss have never exhibited any of the risk factors, thus the hearing screening is recommended to all neonate and the TEOAE is an useful procedure to be used at neonatal population.

White; Behrens (1993) with the Rhode Island Hearing Assessment Project, developed the first large scale clinic experiment with TEOAE in the USA. In normal nurseries and in intensive care units the prevalence of sensorineural hearing loss was 1.5 to 5.95 per 1000 neonates. The results of the Rhode Island Project have enhanced the need of universal hearing screening, before the neonate leaves the hospital.

Despite the fact that this procedure is internationally recognized as the most promising for neonatal hearing screening, large scale national studies are necessary to determine the characteristics of TEOAE, in order to establish some useful criteria in deciding if TEOAE could be considered as normal or altered in a screening test, with a greater power of decision. Thus, the present study has the purpose to determine the characteristics of TEOAE in neonates tested in a universal hearing screening program in a university hospital of Sao Paulo.

Methods

Population of study

For this study, 1000 neonates with born at University Hospital Nursery – USP, between March 10 and July 8 of 2003 were evaluated, 887 without risk factor for hearing loss (455 males and 432 females) and 113 neonates with at least one risk factor for hearing loss (JCIH, 2000), 56 males and 57 females.

The inclusion criterion selected the neonates with presence of TEOAE with general reproducibility ³ 50%, reproducibility specific on higher frequencies > 70% and stability ³ 70%.

Equipment

. ILO 292 / ECHOPORT PLUS - Otodynamics Analyser – which allows the recording of TEOAE · Portable computer KDS, with Pentium III processor and colored monitor, in which is installed the ILO 292 version 5.61.

Procedure

The study was approved by the HU-USP ethics committee (291/02). Written informed consent was obtained from the parent or guardian of each neonate tested in this study. The anamneses registered data related to health during the gestational and neonatal period, and the family communication aspects (hearing and language). The risk factors for hearing loss were registered.

The neonate was positioned in normal cradle, preferable while they were naturally asleep, and the TEOAE probe was adapted on external ear, with an soft latex olive. Half of the tests were initiated by the right ear and the other half by the left ear.

The hearing screening at the nursery occurred between 48 and 60 hours of age during the admission on nursery or mother and child's ward from Monday to Friday. The neonates discharged from hospital on weekend or holidays and who were not tested for hearing loss were referred to clinical screening in 2 to 8 weeks of age (Durante et al., 2003; 2004a; 2004b).

It was used broadband stimulus click (transient) with intensity of 78 – 83 dB peak, non linear mode, eliminating the occurrence of artifacts, and allowing the clinical application of the experiment. Besides, the quickscreen mode, indicated to neonatal screening, was selected. The TEOAE were collected until 50 quiet sweeps were recorded in each ear and

the other parameters of inclusion were achieved.

Statistics

For each experimental unity the following explicative data were registered: conceptional age, gender, prenatal and perinatal problems, risk for hearing loss, site of the screening (nursery or clinic).

And the following response data for each ear: TEOAE response level and per frequency bandwidths (0.7 ; 1.5; 2.2; 3.0; e 3.7 kHz) (in dB), and the test time duration (in seconds).

The statistical analyses were realized with the "Centro de Estatística Aplicada do Instituto de Matemática e Estatística da Universidade de São Paulo (CEA-IME USP)".

A model of analysis of multivaried variance (MANOVA) was adjusted to the TEOAE level and to the duration of the examination. The residual graphic analysis showed that for all models, the suppositions were satisfied (Barroso et al., 2003).

Results

This study presents the TEOAE median level collected in a great number of infants, what allowed the calculation of tables of reference for the OAE levels for the response and for frequency bands. There were no differences between the responses of : neonates with or without risk for hearing loss, term or premature birth, or neonates with or without pre and perinatal problems ($p>0.17$).

For the 0.7 kHz frequency band the gender was not significant (gender $p=0.203$) so the percents were calculated just for each ear (Table 1). For the other frequency bandwidth and for the response the percents were calculated according to gender and ear, once both were significant ($p<0.01$) (Tables 2 to 5).

In addition, the duration of the examination per ear was analyzed according to the infant's age at the moment of the screening. The data analysis showed that the duration of the examination varied according to the site where the screening was performed ($p < 0.001$), e.g. the time was shorter when the screening was performed at the nursery (ages 1 to 6) compared to the clinic (ages 7 and 8) (Graphic 1).

TABLE 1. Percents of TEOAE level for the 0.7 kHz frequency bandwidth, per ear.

Orelha		Percentis						
	N	5%	10%	25%	50%	75%	90%	95%
direita	360	0	0,00	0,58	2,87	5,17	7,23	8,47
esquerda	342	0	0,00	0,70	2,66	4,62	6,39	7,45

TABLE 2. Percents of TEOAE level for males right ear, per frequency bandwidth.

		Percentis						
Freqüência	N	5%	10%	25%	50%	75%	90%	95%
resposta geral	511	11,09	13,14	16,58	20,39	24,21	27,64	29,70
1,5khz	431	1,83	4,14	8,00	12,29	16,58	20,44	22,75
2,2kHz	438	6,04	8,24	11,90	15,97	20,04	23,70	25,89
3,0kHz	437	5,76	8,09	12,00	16,33	20,66	24,57	26,90
4,0kHz	440	4,85	7,28	11,35	15,87	20,39	24,45	26,88

TABLE 3. Percents of TEOAE level for males left ear, per frequency bandwidth

		Percentis						
Freqüência	N	5%	10%	25%	50%	75%	90%	95%
resposta geral	511	10,07	12,15	15,62	19,47	23,33	26,80	28,87
1,5kHz	425	1,56	3,85	7,68	11,93	16,18	20,00	22,29
2,2kHz	439	6,27	8,46	12,12	16,18	20,25	23,90	26,09
3,0kHz	439	5,87	8,14	11,93	16,14	20,36	24,15	26,42
4,0kHz	440	4,76	7,14	11,12	15,54	19,96	23,94	26,32

TABLE 4. Percents of TEOAE level for females right ear, per frequency bandwidth.

		Percentis						
Freqüência	N	5%	10%	25%	50%	75%	90%	95%
resposta geral	487	12,76	14,82	18,25	22,07	25,88	29,32	31,37
1,5kHz	416	2,86	5,17	9,03	13,32	17,60	21,46	23,77
2,2kHz	422	7,36	9,56	13,22	17,29	21,36	25,02	27,21
3,0kHz	421	6,52	8,85	12,75	17,09	21,42	25,32	27,66
4,0kHz	426	6,52	8,96	13,02	17,54	22,06	26,12	28,56

TABLE 5. Percents of TEOAE level for females left ear, per frequency bandwidth.

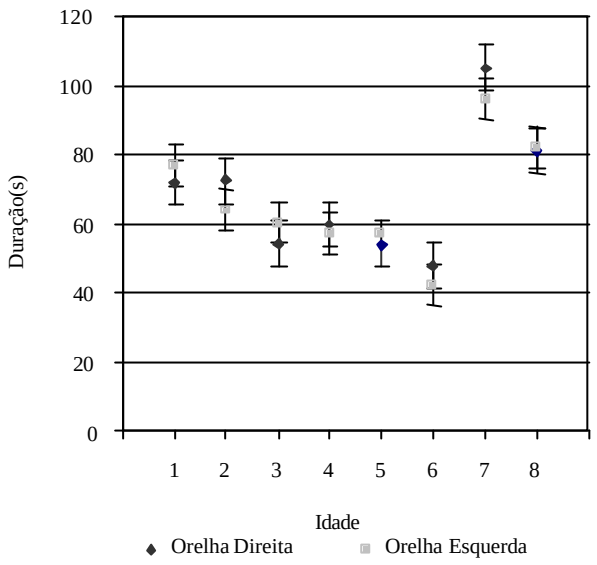
		Percentis						
Freqüência	N	5%	10%	25%	50%	75%	90%	95%
resposta geral	486	11,72	13,79	17,26	21,12	24,97	28,44	30,52
1,5 kHz	415	1,98	4,27	8,10	12,35	16,60	20,42	22,71
2,2 kHz	421	6,56	8,75	12,40	16,47	20,53	24,19	26,38
3,0 kHz	422	6,85	9,12	12,91	17,12	21,34	25,13	27,40
4,0 kHz	422	6,55	8,93	12,90	17,32	21,74	25,72	28,10

Discussion

In this paper the TEOAE showed larger levels in females and right ears, this fact was also observed by other authors (Table 6), reinforcing that the hearing sensitivity is stronger in females and right ears (Kannan et al., 1974) and that this gender differences emerge early in development. The higher OHC count in females (Wright et al., 1987), gender with a a higher prevalence of OAE (Cassidy; Ditty, 2001). The spontaneous otoacoustic emissions (SOAE) are found in the absence of acoustic stimulation, and are also more prevalent in females and right ears, and despite the uncertain clinical application their presence have impact on TEOAE measure (Probst et al., 1986). These gender differences could account for the TEOAE higher level observed in females, and the fact that maximum cochlear length is already achieved at birth enables that these gender differences could be observed on neonatal period.

In Brazil, Fuzetti (2002) studied the occurrence

GRAPHIC 1. TEOAE test median duration (in seconds) by ear and age.



Legend for the infant age:

Idade	
1	> 24h < 36h
2	> 37h <48h
3	> 49h < 60h
4	> 61h e < 72h
5	até 10 dias
6	> 10 dias sem alta prévia
7	Ambulatório 2-4 semanas
8	Ambulatório 5-8 semanas

TABLE 6 . TEOAE level in neonates according gender, ear and author.

Autor	Nível das EOAT - dB NPS			
	Feminino	Masculino	OD	OE
Aidan et al. (1997)	22,1	21,4	22,4	21,1
Newmark et al. (1997)	23	21,5	22	21
Basseto (1998)	13,5	13	13,7	12,9
Durante (2000)	17,7	16,3	17,7	16,2
Durante (2004)	17,9	16,6	17,9	16,5
Presente estudo	21,6	19,9	21,2	20,3

of SOAE and TEOAE in 52 neonates. The author observed the occurrence of SOAE in 78% of the right ears and 66.7% of the left ears. Besides, there was a significant ($p<0.010$) statistical difference between the TEOAE level medians on the ears that presented the SOAE and those that did not, and the ears with SOAE revealed stronger response levels.

Soares et al. (1998) observed the occurrence of SOAE in 52.4% of females and in 27.5% of males, and the stronger TEOAE response levels were collected in frequencies with presence of SOAE in 63.6% of time.

On the other hand, the difference observed between ears, usually associated with a right-ear sensitivity advantage and the left-hemispheric advantage in speech perception and language function (Previc, 1991), has been recently associated with the auditory efferent control (Newmark,1997). Studies done by Khalfa et al. (1998) in adults and by Morlet et al. (1999) and Durante (2004) in neonates, have shown that the TEOAE suppression effect is stronger on right ears providing evidence that the efferent activity is asymmetric between the ears, and reinforces the acoustic signal detection on the presence of competitive noise on the right ear. Thus either the TEOAE suppression effect or the TEOAE level constitute valid and independent markers of peripheral auditory lateralization. The two markers reflect specific mechanisms with no apparent link, and their asymmetries are not related. Thus, the lateralization of OHC motility as reflected by TEOAE does not influence the asymmetry in OHC active mechanisms efferent regulation (Khalfa et al., 1998).

Another significant aspect presented by this paper was the distinction between the time necessary to record TEOAE in infants at the nursery and at the clinic. The mean duration time is similar to the observed at the literature (Table 7), however as in Kok et al.(1994) study at the nursery the test was faster, this is probable associated to the infant state, because at the clinic the infants are more often awake and restless the test would take longer. At the nursery because of the infants hospitalization it is possible to perform the test at the natural sleep, and how nearest from the discharge faster is the examination (Graphic 1), Korres et al. (2003) reported similar findings at the growth of OAE during the first days postpartum.

It is important to notice that the TEOAE response level in infants with risk for hearing loss was not different from the response in infants without risk. Also was no difference between the

TEOAE response level from mother's infants with or without conceptional problems, and between the infants with or without perinatal problems. And finally it was not find differences between the TEOAE response level from term or premature groups, suggesting that at birth the OHC functional maturity is completed. These results are similar to the findings reported in Garcia et al. (2002), that could collect TEOAE in neonates from at least 27 weeks of conceptional age. So this paper presents results that do not differ from the international literature (Norton et al., 2000; Cone-Wesson et al., 2000) and suggest that the neonatal hearing screening pass/fail criterion, for TEOAE protocol, could be universal.

When compared to the other frequency bands the 0.7 kHz presented the smallest response level, smaller than 9 dB at 95 percent of all trials (Table 1), what has been usually justified by the physiologic noise, characteristic of this age (Kemp, 2002).

At 1.5 kHz frequency band only 5% of neonates presented response level smaller than 3 dB for both ears and for both genders, illustrating that a minority show low response levels at this frequency band (Tables 2 to 5).

However, the higher frequency band (2.2, 3.0 e 3.7 kHz) showed response levels with larger medians, 15 dB for males and 17 dB for females. The response was larger than 10 dB in 95% of the studied neonates, for both ears and for both genders, what agrees with papers that found TEOAE from 15 dB to levels greater than 30 dB (Kemp, 2002). In this work 10% of the infants showed response levels greater than 27 dB, for both genders (Tables 2 to 5).

TABLE 7. TEOAE test bilateral median duration (in seconds) in infants according author.

Autor	Duração do Exame de EOA(s)
Aidan et al. (1997)	89
Paludetti et al. (1999)	98
Norton et al. (2000)	120
Raineri1 et al. (2001)	82
presente estudo - maternidade	90
presente estudo - ambulatório	180

Conclusions

The study allowed the elaboration of TEOAE analysis reference tables which can be used for population with the same characteristics of the studied sample.

The TEOAE level was influenced by gender and ear, except for 0.7 kHz, however there was no differences between the responses from neonates with and without risk factor for hearing loss, allowing the adopting of universal pass/fail criterion. Besides, the screening should be done preferable at the nursery, site that allows a shorter time test.

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