AUDITORY STEADY-STATE RESPONSES AIR AND BONE CONDUCTED IN CHILDREN FROM ZERO TO SIX MONTHS WITH AND WITHOUT CONDUCTIVE IMPAIRMENTS

Potencial evocado auditivo de estado estável por via aérea e via óssea em crianças de zero a seis meses sem e com comprometimento condutivo

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ABSTRACT

Purpose: check the feasibility of searching the minimum response of the Auditory Evoked Potential Steady State by air and bone conduction in children from birth to six months and measure the "gap" air-bone of children with impairment conductive. **Methods:** we evaluated 60 children from birth to six months, 30 with and 30 without impairment conductive, divided into a control group and study group. Were measured acoustic impedance, otorhinolaryngological evaluation, and the Auditory Evoked Potential Steady State by air and bone conduction. The Auditory Evoked Potential Steady State was carried by air with insert earphones and bone with bone vibrator. By airway responses were surveyed in both ears and bone captured only the left ear. **Results:** in the control group, there was a predominance of type curve "A". In the study group, there was a predominance of type curves "B" and "C". In otorhinolaryngological evaluation found in the control group showed up normal. In the study group, opacity and tympanic membrane retraction. The Auditory Evoked Potential Steady State in the control group by air responses were around 17.2, 26.2, 22, 7 and 19.8 dBHL at frequencies 500 to 4 kHz and bone conduction between 18.8 to 20dBHL. In the study group by airway responses were 53, 56, 50.2 and 48dBNA to 500 to 4kHz and bone of 25, 25, 20 and 20dBHL. **Conclusion:** it was possible to perform the Auditory Evoked Potential Steady State by air and bone conduction in children from birth to six months of age and the "gap" air-bone was around 20dB in children with impairment conductive.

KEYWORDS: Evoked Potentials, Auditory; Auditory Perception; Early Diagnosis; Ear, Middle; Hearing

INTRODUTION

When approaching children's development, all auditory information is important, mainly in the first months of life. Any hearing loss during this period, even if they are conductive and temporary, may present implication in the future, including worse learning performance.

In recent years, it has been observed improvements in the children's hearing diagnosis, mainly as a consequence of technological developments and of the introduction of new pediatric evaluation techniques.

With the newborn hearing screening, even younger children have needed complete hearing evaluation. To evaluate those infants, it is necessary to perform some auditory tests and otorhinolaryngologic evaluations. In those evaluations, it is

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necessary to verify if there is hearing alteration, the type of alteration, if it is conductive or sensorineural and the degree of the loss. That information is determined by the auditory air and bone conducted thresholds.

The otorhinolaryngologic examination is essential to confirm the conductive alterations and to establish proper clinical treatment. The acoustic immittance measures contribute with information about the tympano-ossicular system mobility and about the integrity of the auditory pathways in this level. Those measures are used in clinical practice with lactating, because they are an objective evaluation, providing results of tympanograms and reflex acoustic.

As a way to complement the children's auditory diagnosis, there is the Auditory Steady-State Response (ASSR) as a new electrophysiological technique. The ASSR is an examination which provides facilities and efficiency to obtain the responses, objectivity in the registration analysis, selectivity of frequencies of responses, and higher possibility to detect auditory responses than other objective methods[1].

The ASSR can be researched through bone and auditory pathways, being possible to determine the presence and magnitude of the conductive hearing impairment, through the difference between the minimal levels of air and bone responses; this makes the examination a useful tool also in the evaluation of middle ear diseases.

Some international studies reported agreement between the minimal levels of response of the behavioral evaluation with the ASSR through air way in children with conductive impairments[2]. That agreement was also evidenced in the research of the minimal levels of behavioral and electrophysiological responses, bone way, of that population[3,4]. However, national studies about bone way ASSR were not found.

Based on what was previously demonstrated, the purpose of this study was to verify the viability to research the Minimum Response Levels (MRL) of the Auditory Steady-State Responses (ASSR), air and bone conducted, in children to six months and to measure the air-bone gap in children with conductive auditory impairments.

METHODS

This study was approved by the ethics committee, research protocol n. 1191/10 and it is according to the criteria of the administrative rule 196/96 by the national health department regarding research with human beings. All parents of the studied children authorized their participation in the research and display of results, according to the declaration 196/96.

It is a transversal, contemporaneous study with groups' comparison. The research was performed from July 2008 to January 2011, in the *Núcleo Integrado de Atendimento, Pesquisa e Ensino em Audição* – NIAPEA, Speech-Language Pathology, *Universidade Federal de São Paulo* and in the Otorhinolaryngology Clinic at the same institution.

The subjects of this study were 60 children, male and female, from birth day to six months. There were two groups: Control group: 30 children from birth day to six months, 20 (66.7%) male and 10 (33.3%) female, without middle ear alterations; and study group: 30 children from birth day to six months, 18 (60%) male and 12 (40%) female, with middle ear alterations.

The eligibility criteria allowed including in the study only children whose otorhinolaryngologic evaluation was compatible with the tympanometry, as to identify normal cases as middle ear alterations.

The children who were excluded of the sample presented improper formation of the ear canal, because it would preclude the evaluations, children with neurological alterations and/or genetic syndromes, and sensorineural hearing loss.

To identify the conductive alteration, it was performed the otorhinolaryngologic evaluation and the acoustic immittance measures (tympanometry and acoustic reflexes). The medical evaluation was considered as normal, or with presence of retracted hyperemic, opaque tympanic membrane. The tympanometry was researched with 1000Hz probe tone. The curves were classified in: Type A Curve – unique admittance peak from -150 and + 100 daPa and volume from 0.2 to 1.8ml; Type D Curve – curve in double peak; Assimetric Curve – peak with high positive pressure; Type C Curve – admittance peak replaced to negative pressure; Inverted Curve (I) – with inverted configuration in relation to the normal curve; and Type B Curve – flat curve without admittance peak[5-8].

To discard the cochlear impairments of children from the control group, it was performed the research of the transient-evoked otoacoustic emissions (TEOAE's). For the TEOAE's, the presence of the signal-noise relation should be higher than 6dB with reproducibility higher than 50% and the stability should be higher than 70%. The used equipment was the ILO-96 otoacoustic emissions analyzer, coupled with a computer, using the Quickscreen program.

To identify the Minimal Response Levels through air and bone threshold of the children with and without conductive impairments, it was used the Auditory Steady-State Responses (ASSR) air conducted (with insertion phones) and bone conducted (bone vibrator). The evaluated carrier frequencies were 500, 1000, 2000 and 4000Hz, and the frequencies modulation were 77, 85, 93 and 101 Hz for the left ear and 79, 87, 95, 103 Hz for the right ear. The type of modulation used was amplitude modulated (AM), 100%. It was used amplification of 100000 times, with high-pass filter of 30Hz and low-pass of 300Hz. The stimuli presentation was ipsilateral, with 400 stimuli in each intensity, presented in descendent way, with 10 dBNPS variation, in order to detect the minimal levels of electrophysiological response. When air conducted, the responses were researched in both ears and when bone conducted, it was picked up information only from the left ear (random choice). It is highlighted that the minimal response levels were performed in dBNPS, with the results converted to dBNA, according to the equipment's conversion table. The used equipment was the Smart EP by Intelligent Hearing System (IHS).

The auditory evaluations were performed by the researcher and the otorhinolaryngologic evaluation was performed by a specialist in the clinic. All the evaluations (including the otorhinolaryngologic evaluation) were performed in the same day.

The following statistical tests were used: Mann-Whitney and Confidence Interval for the average, rejecting the nullity hypotheses when the confidence interval was equal or lower than 5%, being significant when p ≤0.005.

RESULTS

There was no statistically significant difference between male and female in the comparison intra and inter groups. Thus, the children were grouped not considering that variable.

The age average of the control group was 2.4 months and the average of the study group was three months.

About the measures of acoustic immittance, it was observed higher occurrence of normal tympanometry in the control group and altered tympanomtery in the study group (Table 1).

The otoscopy results of both groups can be visualized in Table 2.

Table 1 – Occurrence of tympanometric curves in the control group and in the study group

Tympanometric curve		Control		Study	
		N	%		N
Right ear	A	30	100	0	0
	B	0	0	23	76,7
	C	0	0	7	23,3
Left ear	A	30	100	0	0
	B	0	0	23	76,7
	C	0	0	7	23,3

Table 2 – Distribution of the children in the control group and in the study group in relation to the tympanic membrane conditions

TM		Control		Study	
		N	%		N
Right ear	Normal	30	100	0	0
	Opacity	0	0	21	70
	Retracted	0	0	9	30
Left ear	Normal	30	100	0	0
	Opacity	0	0	21	70
	Retracted	0	0	9	30

In the research of the minimal response levels in the ASSR, air way, for the control group and for the study group, it was observed statistically significant difference. The minimal response levels were lower in the control group in relation to the study group in all evaluated frequencies. The results of the minimal response levels, air conducted, of the right ear are observed in Table 3, and the results of the left ear are observed in Table 4, for both groups.

Table 3 – Descriptive statistics of the minimal response levels for the ASSR air conducted in the RE (dBNA) for the control and study groups by frequency

ASSR AC dBNA – RE	500 Hz		1 kHz		2 kHz		4 kHz	
	Control	Study	Control	Study	Control	Study	Control	Study
Average	17,2	53	26,2	56	22,7	50,2	19,8	48
Median	17	54	24	59	22	52	21	46
Standard Deviation	3,8	3,8	2,8	4,5	3,4	8,7	3,4	6,6
Q1	14	54	24	54	22	47	16	41
Q3	19	54	29	59	22	57	21	56
N	30	30	30	30	30	30	30	30
IC	1,4	1,4	1	1,6	1,2	3,1	1,2	2,4
p-value	0,000*		0,000*		0,000*		0,000*	

*significant p-value < 0.05 (5%); ASSR: Auditory Steady-State Response; RE: right ear; AC: air conducted.
Statistical Tests: Mann- Whitney, Confidence interval for the average

Table 4 – Descriptive statistics of the minimal response levels for the ASSR air conducted LE (dBNA) for the control and study groups

ASSR AC dBNA – LE	500 Hz		1 kHz		2 kHz		4 kHz	
	Control	Study	Control	Study	Control	Study	Control	Study
Average	17,3	52,7	26,3	55,8	22,7	48,2	20,8	48,4
Median	19	54	24	59	22	52	21	46
Standard deviation	3,8	4,1	2,9	5,5	3,4	11,3	4,6	8,2
Q1	14	54	24	54	22	47	16	41
Q3	19	54	29	59	22	57	26	59
N	30	30	30	30	30	30	30	30
IC	1,4	1,5	1	2	1,2	4	1,7	3
p-value	0,000*		0,000*		0,000*		0,000*	

Stable; LE: left ear; AC: air conducted;
*significant p-value < 0.05 (5%); ASSR: Auditory Steady-State Response
Statistical Tests: Mann- Whitney, Confidence interval for the average

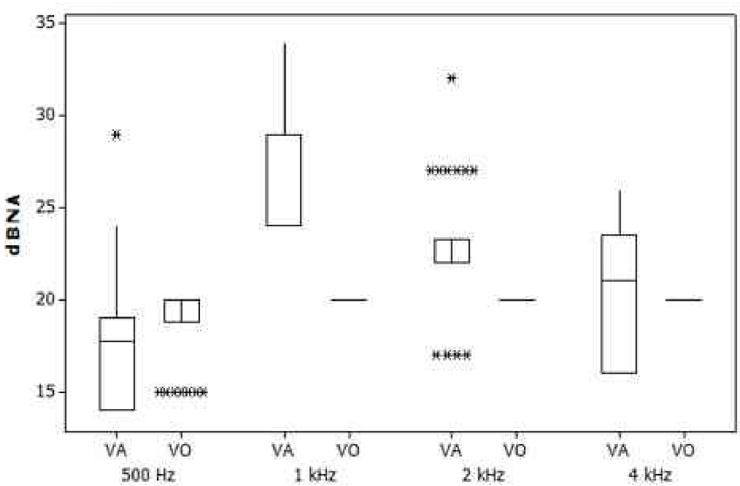
The obtained minimal response levels, bone conducted, varied from 20 to 25 dBNA for both groups. The responses from 500 to 1000Hz of the study group were higher than the responses of the control group (Table 5), with statistically significant difference. In the other frequencies, the responses did not present statistical differences.

It was possible to observe that in the control group there was no air-bone gap, with small difference between air and bone way. In the study group, it was observed air-bone gap with difference between air and bone way (Figures 1 and 2).

Table 5 – Descriptive statistics of the minimal response levels for the ASSR bone conducted in (dBNA) for the control and study groups

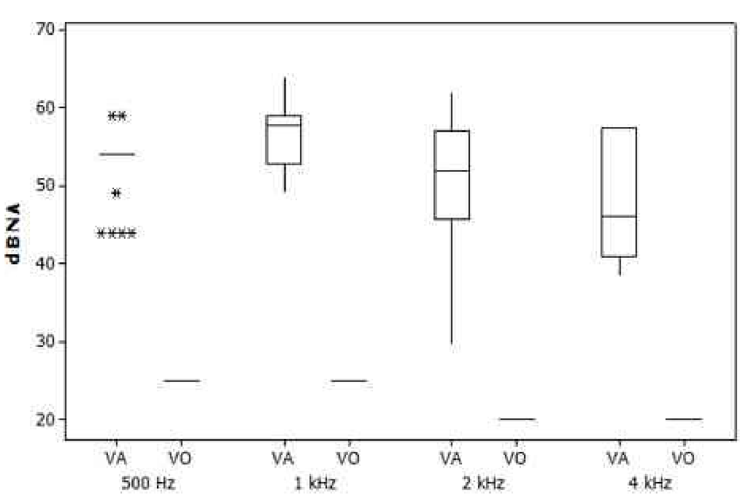
ASSR BC dBNA	500 Hz		1 kHz		2 kHz		4 kHz	
	Control	Study	Control	Study	Control	Study	Control	Study
Average	18,8	25	20	25	20	20	20	20
Median	20	25	20	25	20	20	20	20
Standard deviation	2,2	0	0	0	0	0	0	0
Q1	20	25	20	25	20	20	20	20
Q3	20	25	20	25	20	20	20	20
N	30	30	30	30	30	30	30	30
IC	0,8	- x -	- x -	- x -	- x -	- x -	- x -	- x -
p-value	0,000*		0,000*		1		1	

*significant p-valor < 0.05 (5%);
ASSR: Auditory Steady-State Response; BC: bone conducted;
Statistical Tests: Mann- Whitney, Confidence interval for the average



AC: air conducted; BC: bone conducted; ASSR: Auditory Steady-State Response

Figure 1 - Box-Plot Figure VA (AC)/VO (BC) in the ASSR, dBNA x Hz – Control group



AC: air conducted; BC: bone conducted; ASSR: Auditory Steady-State Response

Figure 2 - Box-Plot Figre VA(AC)/VO(BC) in the ASSR, dBNA x Hz – Study Group

DISCUSSION

In this study, the minimal response levels found for ASSR, air way, in the group of children without conductive impairments for 500, 1000Hz, 2000Hz and 4000Hz was between 15.7 and 26.5 dBNA (Tables 3 and 4). Those values are compatible with the results found in literature in relation to normality of responses for ASSR.

Several authors found minimal levels compatible with the ones from the present study[9-12]. Researchers[13] performed studies with ASSR in children with normal hearing and they found thresholds in dBNA in 32.3 (±7.5) for 500Hz; 32.5 (±6.6) for 1KHz; 24.3 (±6.3) for 2KHz and 28.1(±7.5) for 4KHz. So, considering the standard deviations, the results are similar to the ones obtained in the present study.

In the study group (children with conductive impairment), the minimal response levels of the ASSR, air conducted, for 500, 1000Hz, 2000Hz and 4000Hz varied between 35.5 and 56.0 dBNA (Tables 3 and 4). Those minimal response levels compatible with moderate conductive hearing loss agree with literature[2,14-16].

Besides, for the study group, it was observed that the frequencies of 500 and 1000Hz, air conducted, presented results lower than 2000 and 4000Hz, what would be expected in the audiometric configuration of patients with conductive impairments. That data agree with another study[4] in which the authors found minimal levels for the ASSR better than in 2000Hz and 4000Hz.

The ASSR, performed bone conducted, presented very similar results among the frequencies 500, 1000, 2000 and 4000Hz in the study and in the control group (Table 5). The obtained results agree with the recommendation of other authors[17]. Those authors verify that studies should not restrict the research to threshold obtained air way, because this fact may lead to false positive results for sensorineural hearing loss.

In the control group and in the study group the ASSR results bone conducted are similar. In the control group they vary from 18.8 dBNA to 25 dBNA and in the study group they vary from 20.0 to 25.0 dBNA. It was observed that in the study group the minimal response levels for the frequencies of 500 and 1000Hz bone conducted were a little higher, what was expected, because of the children's conductive impairments. That fact may be explained in a way that the neonates' middle ear is a system which is surrounded by mass and by low resonance frequency[18].

In the bone conducted research, it was not possible to obtain minimal response levels lower than 20 dBNA in both groups, because of the difficulty of response stability which is necessary in the ASSR. Sometimes, the response was 15 dBNA, but it did not stabilized during the presentation of the three necessary sweeps blocks. Thus, the presented minimal levels were classified as reliable.

The results of the present study agree with another research[3] with a group from the same age group, that obtained bone conducted responses about 16 (11), 16 (10), 37 (10) and 33 (13) dBNA for the frequencies from 500 to 4000 Hz. The present study was similar to another one by other researchers[4] who researched bone conducted ASSR in children with normal hearing and with conductive impairments. The authors found similar results for bone conducted ASSR in both groups, what agrees with the current study. Other researchers[19] performed a study with adults, obtaining minimal response levels which are also similar to the ones found in the present study.

As the ASSR was verified bone and air conducted, it was possible to measure the air-bone gap in the control group and in the study group (Figures 1 and 2). In the control group, it was possible to observe that the difference between air and bone conduction was very small (5dB) or inexistent, resulting in absence of air-bone gap. In the study group, it was possible to observe that there was difference between air and bone conduction which varied from 28 to 31dBNA in the four evaluated frequencies. The air-bone gap confirmed the configuration of conductive hearing loss with moderate level. Some researchers[4], in a study with a little older children found differences between air and bone conduction of 18.8; 16.0; 3.8 e 7.4 for 500, 1000, 2000, 4000Hz, lower than the results of the current study.

The moderate degree conductive hearing loss may bring several negative consequences to children and it needs medical care and proper treatment. Some studies have revealed that as early children present their first middle ear alteration, higher are the probabilities of repetitions during the first and second years of life, what increases the need of attention and treatment[20].

CONCLUSION

It was possible to perform the ASSR research, air and bone conducted, in children from birth day to six months and to measure the air-bone gap during the periods of conductive impairments. It is viable its use for the cases of middle ear impairments. The magnitude of hearing loss found for the cases of conductive impairment was moderate degree with gaps of about 20dB.

RESUMO

Objetivo: verificar a viabilidade de pesquisar os níveis mínimos de resposta do Potencial Evocado Auditivo de Estado Estável por via aérea e via óssea em crianças do nascimento aos seis meses e mensurar o "gap" aéreo-ósseo de crianças com comprometimento condutivo. **Métodos:** avaliadas 60 crianças, 30 com comprometimento condutivo e 30 sem, distribuídas em grupo controle e estudo. Foram realizadas medidas de imitância acústica, avaliação otorrinolaringológica e Potencial Evocado Auditivo de Estado Estável por via aérea e via óssea. O Potencial Evocado Auditivo de Estado Estável foi realizado por via aérea com fones de inserção e por via óssea com vibrador ósseo. Por via aérea as respostas foram pesquisadas em ambas as orelhas e por via óssea captadas somente da orelha esquerda. **Resultados:** no grupo controle, houve predominância de curva do tipo "A". No grupo estudo, de curvas tipo "B" e tipo "C". Na avaliação otorrinolaringológica do grupo controle evidenciou-se normalidade da membrana timpanica. No grupo estudo, opacidade e retração. No Potencial Evocado Auditivo de Estado Estável do grupo controle por via aérea as respostas foram em torno de 17,2; 26,2; 22, 7 e 19,8dBNA nas frequências 500 a 4KHz e para via óssea entre 18,8 a 20dBNA. No grupo estudo por via aérea as respostas foram de 53; 56; 50,2 e 48dBNA e por via óssea de 25; 25; 20 e 20dBNA. **Conclusão:** foi possível realizar a avaliação dos Potenciais Evocados Auditivos de Estado Estável por via aérea e via óssea em crianças até os seis meses e o "gap" aéreo-ósseo foi em torno de 20dB nas crianças com comprometimento condutivo.

DESCRITORES: Potenciais Evocados Auditivos; Percepção Auditiva; Diagnóstico Precoce; Orelha Média; Audição

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