Original Article

Artigo Original

Electrophysiological characterization of hearing in small for gestational age premature infants

Caracterização eletrofisiológica da audição em prematuros nascidos pequenos para a idade gestacional

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Keywords

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ABSTRACT

Purpose: To characterize the Auditory Brainstem Response (ABR) of small for gestational age preterm newborns and to compare the findings to those of appropriate for gestational age premature newborns in order to verify whether the small for gestational age condition is a risk factor for hearing loss. **Methods:** This prospective cross-sectional multicenter study evaluated 72 preterm newborns of both genders (35 small and 37 appropriate for gestational age), who were born at 30 to 36 weeks of gestational age and were evaluated before hospital discharge. Only newborns with present transient evoked otoacoustic emissions and tympanometry type A were included. The ABR was performed with click stimuli. The quantitative data analysis was performed using mean and standard deviation measures for each group. For qualitative analysis, the ABR results were classified as normal or altered according to the absolute latencies of waves I, III, V and interpeaks I-III, III-V, I-V. The analysis was carried out considering the age of the newborn at the time of examination. **Results:** Alterations were evident in 32 newborns (44.44%), being 15 small (43%) and 17 appropriate for gestational age (46%), with no between-groups difference. Of the 15 small for gestational age newborns with altered ABR, six presented as auditory risk only the small for gestational age condition. In the group of adequate for gestational age newborns, there was a higher occurrence of alteration in males. **Conclusion:** There was no difference in responses of auditory evoked potential between small and appropriate for gestational age preterm newborns. Therefore, the condition does not behave as a risk factor for retrocochlear impairment.

Descritores

Potenciais evocados auditivos do tronco encefálico
Audição
Transtornos da audição
Recém-nascido
Prematuro

RESUMO

Objetivo: Caracterizar as respostas do Potencial Evocado Auditivo de Tronco Encefálico em recém-nascidos pré-termo pequenos para idade gestacional, comparando-as às de recém-nascidos pré-termo adequados para idade gestacional, verificando se a condição de pequeno para a idade gestacional é indicador de risco para alteração auditiva retrococlear. **Métodos:** Estudo multicêntrico transversal prospectivo. Avaliou-se 72 recém-nascidos pré-termo, 35 pequenos e 37 adequados para idade gestacional de ambos os gêneros, com idade gestacional de 30 a 36 semanas e avaliados na pré-alta hospitalar, com presença de emissões otoacústicas evocadas por estímulo transiente e timpanometria tipo A. A análise quantitativa dos dados foi feita baseada na média e desvio-padrão das latências das ondas I, III, V e interpicos I-III, III-V, I-V para cada grupo. Para análise qualitativa, os resultados dos potenciais evocados auditivos foram classificados em alterado ou normal mediante a análise das latências absolutas das ondas I, III, V e dos interpicos I-III, III-V, I-V, considerando-se a faixa etária no momento do exame. **Resultados:** Evidenciaram-se alterações em 32 crianças (44,44% do total), sendo 15 recém-nascidos pequenos (43%) e 17 adequados (46%), não havendo diferença entre os grupos. Dos 15 recém-nascidos pequenos com potencial evocado auditivo alterado, seis tiveram como risco auditivo apenas o fato de ser pequeno para a idade gestacional. No grupo adequado para idade gestacional, houve maior ocorrência de alterações no gênero masculino. **Conclusão:** Não houve diferença nas respostas do potencial evocado auditivo entre os recém-nascidos pré-termo pequenos e adequados, de forma que a condição pequeno não se revelou risco para alteração retrococlear.

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Multicentrical study carried out at the Graduate Program in Rehabilitation Sciences, Department of Physical Therapy, Speech-Language Pathology and Audiology, School of Medicine, Universidade de São Paulo – USP – São Paulo (SP), Brazil, and at the Hospital São Paulo, Universidade Federal de São Paulo – UNIFESP – São Paulo (SP), Brazil.
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INTRODUCTION

The appropriateness of birth weight is a strong risk predictor for delays in the psychomotor development. Therefore, the low birth weight (which can be derived both from prematurity and from intrauterine growth restriction – IUGR) and the preterm condition are the most important factors in determining neonatal morbidity and mortality[1-3].

The etiology of preterm birth is multifactorial. The fragility of premature infants contributes to the possibility of imminent risks, hazards and several types of sequelae with different consequences and interveniences in the process of child development and growth. Thus, it is necessary to consider the risks and prognostics in order to establish and promote preventive measures in this population[3].

Authors have emphasized that preterm infants with low birth weight are at risk and are from seven to ten times more likely to develop problems such as cerebral palsy, deafness and mental retardation in relation to term infants weighing over 2500 g[4].

There is a consensus in the literature that infants born small for gestational age (SGA) may struggle during neuro--psychomotor development, including hearing and language development[5-8].

The term SGA describes an infant whose birth weight in relation to gestational age is below the 10th percentile in the growth curve that relates birth weight with gestational age[9]. The condition of SGA is often associated with IUGR which causes are various such as smoking, maternal low height, drug use, congenital infections among others.

Small for Gestational Age (SGA) newborns can be classified into two subgroups according to the period in which they suffered injuries during intrauterine life: SGA newborns with asymmetrical or disproportional pattern - whose condition likely occurred in late pregnancy by placental insufficiency; and SGA newborns with symmetrical or proportional pattern - whose condition likely occurred from the beginning of pregnancy, possibly causing major commitments to the fetus[2]. The literature indicates that, compared with infants born appropriate for gestational age (AGA), SGA infants have a disadvantage in neuro psychomotor and language development[6,10-12].

Auditory skills, as well as oral language[2,13-15], develop in the first two years of life. This fact highlights the importance of detecting and monitoring infants who are at risk during this period.

The Auditory Brainstem Response (ABR) is considered the "gold standard" for the diagnosis of auditory nerve and auditory pathways integrity in the central nervous system of neonates. It also allows monitoring the maturation of the central auditory system in the brain stem that occurs from the first months of life until around 18 months, when the responses become similar to those of adults[16].

The purpose of this study was to characterize the ABR responses of SGA preterm newborns and to compare the findings to those of premature infants considered appropriate for gestational age (AGA) in order to verify whether the SGA condition can be considered a risk factor for retrocochlear alteration.

METHODS

This multicenter study initiated after approval by the Ethics Committee of Universidade de São Paulo (CAPPesq HCFMUSP Number 372/10), Hospital Universitário (CEP-HU/USP Number 1009-10; SISNEP CAEE 0037.0.198.000 -10) and Universidade Federal de São Paulo (CEP-UNIFESP Number 1235/11).

Following the principles of ethical research involving humans, mothers and/or caregivers who agreed to the participation of newborns in this study signed a consent form in which all procedures were described according to Resolution 196/96.

The sample consisted of 72 preterm infants born at a gestational age between 30 weeks and five days (30 5/7) and 36 weeks and five days (36 5/7) who were assessed before hospital discharge. Of the total sample, 35 newborns were classified as SGA and 37 as AGA according to the percentiles classification criteria adopted at the two institutions participating in the study[9].

The Study Group (SG) consisted of 35 SGA preterm newborns (PTN) with 21 females and 14 males. The control group (CG) consisted of 37 AGA preterm newborns, with 25 females and 12 males.

The classification of SGA preterm newborns can be obtained by calculating the Rohrer's Ponderal Index (PI), which parameters are defined by the weight (in grams) divided by cubed height (cm^3), multiplied by 100. If the IP is ≥ 2.49, SAG is considered symmetrical or proportional; if IP is <2.49, SGA is considered asymmetrical or disproportional.

The first phase of the study consisted on the reading of medical records of newborns to collect data on eligibility criteria (AGA, SGA and preterm). These data included anthropometric measurements as well as the gestational age based on last menstrual period (LMP) and confirmed by ultrasonography.

Another eligibility criterion of the sample was the presence of bilateral transient evoked otoacoustic emissions (TEOAE) and tympanometry type A[15].

Newborns who had encephalopathy, malformations and conductive and/or cochlear alterations were excluded from the sample and referred for medical evaluation and treatment as well as for audiologic follow-up.

The preparation of all newborns for the tests was carried out as follows: the inspection of the external auditory canal was performed in order to visualize the tympanic membrane with a Welch Allyn® otoscope. Next, newborns were tested for transient evoked otoacoustic emissions (TEOAE) and acoustic immittance (tympanometry) to ensure normality and absence of middle ear impairment, respectively.

To capture TEOAE both the equipment ILO92-Otodynamics® with nonlinear click stimulus type at an intensity between 78 and 83 dB SPL (Research Center of the Department of Physical Therapy, Speech and Occupational Therapy, University of São Paulo) and the automatic equipment AccuscreenPRO portable, GN from Otometrics® (São Paulo Hospital, Federal University of São Paulo) were used. In the latter, the equipment was calibrated by the manufacturer for the automatic analysis of responses to the following

parameters: binomial statistics evaluation method; nonlinear click stimuli in sequence with a speed of 60 Hz and intensity of 70-84 dBSPL (45-60 dBHL with self-calibration depending on the volume inside the ear canal); frequency spectrum from 1.4 kHz to 4 kHz; artifact less than 20%. When these parameters are not obtained, the equipment records "failure". Similarly, when these parameters are obtained, the equipment registers "pass"[17].

The acoustic impedance measurements covered tympanometry with probe tone of 1 kHz performed in middle ear analyzer model AT 235H from Interacoustics®.

To conduct the ABR, the infant remained in the crib or on his/her mother's lap in natural sleep. The medical equipment Smart-EP from Intelligent Hearing Systems® was used for capturing the ABR. The preparation of all newborns for the tests was carried out as follows: cleaning the skin with an abrasive paste and attaching the Meditrace-200 disposable pediatric electrodes from Kendal® in the frontal region (Fpz) and the right and left mastoid (M1 and M2), according to the IES 10-20 standard (International Electrode System) (18). The acoustic stimulus was presented by a pair of insert earphones model 3A, eliciting responses.

The click with rarefied polarity acoustic stimulus was monaurally presented at 80 dBHL to assess the integrity of the auditory pathway, at a presentation rate of 27.7 clicks per second, duration of 0.1 milliseconds (ms), with a total of 2048 stimuli. The recording window of 12 ms was used. The absolute latencies of waves I, III, V, and interpeaks I-III, III-V, I-V were analyzed considering the age of the infants at the time of evaluation.

The ABR responses were qualitatively analyzed and the results were classified as normal and altered, according to the values of absolute latencies of waves I, III and V and interpeaks I-III, III-V and I-V proposed by the Evoked Potential User Manual for the Smart-EP equipment[19]. The post-conceptual age at evaluation was considered.

Quantitative analysis with descriptive measures of mean and standard deviation of absolute latencies and interpeaks was also carried out. For statistical analysis, the confidence interval of 95% and a significance level of 5% were considered and the Chi-square test, Student t-test, independent t test and Fisher's exact tests were applied[20].

RESULTS

The study group comprised of 35 preterm newborns separated into two subgroups for the ABR qualitative analysis: 10 symmetric and 25 asymmetric SGA newborns. No between--group difference was observed when comparing subgroups regarding the proportion of normal and abnormal ABR results (p=1.000) (Table 1). Therefore, further analyses of the SGA group were made considering the complete group.

In the comparative analysis of ABR responses between study (SGA) and control (AGA) groups, alterations were observed in 32 newborns (44.44% of total sample) - 15 SGA newborns (43%) and 17 AGA newborns (46%) – with no significant between-groups difference (p=0.792) (Table 2).

Table 1. Comparative analysis of ABR responses between the symmetrical and asymmetrical SGA PTgroups

PT/SGA	ABR		Total n (%)
	Normal n (%)	Altered n (%)	
Symmetric	6 (60)	4 (40)	10 (100)
Asymmetric	14 (56)	11 (44)	25 (100)
Total	20 (57)	15 (43)	35 (100)

Fisher's Exact test: p=1.000

Note: PT/SGA = preterm small for gestational age; ABR = auditory brainstem response

Table 2. Comparative analysis of ABR responses between the study group (SGA) and the control group (AGA)

Group	ABR		Total n (%)
	Normal n (%)	Altered n (%)	
AGA	20 (54)	17 (46)	37 (100)
SGA	20 (57)	15 (43)	35 (100)
Total	40 (56)	32 (44)	72 (100)

Chi-square test: p=0.792

Note: AGA = adequate for gestational age; SGA = small for gestational age; ABR = auditory brainstem response

With regard to the comparative analysis between female and male participants in the SGA group, no difference was observed regarding the distribution of ABR alteration (p=0.486). However, in the AGA group, the comparison between female and male participants regarding distribution of alteration was significant (p=0.014); male newborns presented a higher number of ABR alterations (Table 3).

The comparative analysis between SGA and AGA male newborns revealed that seven SGA (50%) and nine AGA (75%) newborns had abnormal ABR characterized by increase in absolute latencies of waves III and/or V and interpeaks I-III and/or I-V. These results reveal no difference between SGA and AGA male newborns (p=0.248) (Table 3).

The comparative analysis of ABR responses between SGA and AGA female newborns revealed that among SGA newborns, eight (27%) had abnormal ABR, characterized by increase in absolute latencies of waves III and/or V and interpeaks I-III and/or I-V. As for AGA newborns, eight (32%) showed an increase in absolute latencies of waves III and V. These results showed no difference between SGA and AGA female newborns (p=0.665) (Table 3).

Preliminarily, the results obtained by each group (SGA and AGA) for each ABR parameter (absolute latencies of waves I, III and V and interpeaks I-III, III-V and I-V) were analyzed for each ear in isolation using the paired t-test. The results regarding the above-mentioned comparative analysis are described in Table 4. There were no significant differences between right and left ears in any of the groups.

Thus, since no evident effect of ear was observed, it was possible to analyze each ABR parameter maintaining the comparison between the SGA and AGA groups.

No between-group (SGA and AGA) difference was

Table 3. Comparative between-group (SGA and AGA) and between-gender analysis of ABR responses

ABR	AGA		SGA		Comparison	p-value
	Female (1) n (%)	Male (2) n (%)	Female (3) n (%)	Male (4) n (%)		
Normal	17 (68)	3 (25)	13 (73)	7 (50)	AGA-Gender (1) x(2)	0.014*
Altered	8 (32)	9 (75)	8 (27)	7 (50)	SGA-Gender (3) x (4)	0.486
Total	25 (100)	12 (100)	21 (100)	14 (100)	Female-Group (1) x (3)	0.665
					Male-Group (2) x (4)	0.248**

* Significant values (p≤0.05) – Chi-square test

** Fisher's Exact test (p≤0.05)

Note: AGA = adequate for gestational age; SGA = small for gestational age; ABR = auditory brainstem response

Table 4. Comparison of mean and standard deviation of ABR absolute latencies of waves I, III, V and interpeaks I-III, III-V, I-V in the study (SGA) and control (AGA) groups between right and left ears

Waves and interpeaks		SGA (n=35)		p-value	Result	AGA (n=37)		p-value	Result
		Right	Left			Right	Left		
I	Mean	1.86	1.83			1.83	1.83		
	SD	0.19	0.10	0.222	R=L	0.14	0.15	0.975	R=L
III	Mean	4.76	4.77			4.75	4.76		
	SD	0.24	0.26	0.318	R=L	0.33	0.38	0.789	R=L
V	Mean	7.22	7.23			7.30	7.30		
	SD	0.44	0.44	0.938	R=L	0.36	0.41	0.901	R=L
I-III	Mean	2.92	2.94			2.91	2.91		
	SD	0.25	0.26	0.796	R=L	0.34	0.37	0.995	R=L
III-V	Mean	2.51	2.45			2.60	2.54		
	SD	0.26	0.32	0.113	R=L	0.34	0.35	0.125	R=L
I-V	Mean	5.38	5.39			5.47	5.45		
	SD	0.42	0.41	0.794	R=L	0.44	0.44	0.358	R=L

* Significant values (p≤0.05) – Paired t-test

Note: R =right ear; L= left ear; SD = standard deviation; AGA = adequate for gestational age; SGA = small for gestational age

observed regarding the absolute latency of wave I (p=0.613) as well as for waves III and V (0.908 and 0.510 ms, respectively). There was also no difference between the SGA and AGA groups in the comparative analysis of interpeaks I-III, III-V and I-V (0.721, 0.245 and 0.490, respectively) (Table 5).

The influence of risk factors for hearing loss - as described by the Joint Committee on Infant Hearing (JCIH)[16] and Azevedo[21] – was also analyzed in the population studied. Of the total 35 SGA preterm newborn of the sample, 20 newborns had normal ABR (57%), and 15 (43%) had retrocochlear alterations. Of the 20 newborns who had normal responses on ABR, nine presented as the sole risk factor being a SGA preterm newborn; one had family history of hearing loss in addition to being SGA; ten newborns remained for more than five days in neonatal intensive care unit (NICU), and of these, eight have made use of ototoxic drugs and two had peri intraventricular hemorrhage (PIVH). Of the 15 newborns who had altered responses on ABR, six presented as the sole risk factor being SGA (staying in the NICU for observation for weight gain); nine remained for more than five days in the NICU and made use of ototoxic drugs and a newborn had degree I PIVH; and one had perinatal asphyxia.

Of the total of 37 AGA preterm newborns, 20 had normal

Table 5. Between-group (SGA and AGA) comparison of mean and standard deviation of ABR absolute latencies of waves I, III, V and interpeaks I-III, III-V, I-V

Waves and interpeaks		SGA (n=35)	AGA (n=37)	p-value
I	Mean	1.85	1.83	0.613
	SD	0.15	0.14	
III	Mean	4.76	4.75	0.908
	SD	0.44	0.36	
V	Mean	7.23	7.30	0.510
	SD	0.44	0.38	
I-III	Mean	2.93	2.91	0.721
	SD	0.25	0.35	
III-V	Mean	2.48	2.57	0.245
	SD	0.27	0.58	
I-V	Mean	5.38	5.46	0.490
	SD	0.41	0.43	

Independent t-test (p≤0.05)

Note: SD = standard deviation; AGA = adequate for gestational age; SGA = small for gestational age

ABR (54%), and 17 (46%) had alterations suggestive of central involvement (of these 17, ten newborns had no risk factors for hearing loss, seven remained for more than five days in the NICU and made use of ototoxic drugs). There was no difference in occurrence of central alterations in SGA and AGA newborns with and without associated auditory risks.

The characterization of risk factors in the two studied populations (AGA and SGA) regarding ABR normality and alteration is described in Chart 1.

Chart 1. Influence of risk factors regarding alterations in ABR responses according to group (AGA and SGA)

Group / Indicators	SGA (n=35)		AGA (n=37)	
	Normal	Altered	Normal	Altered
No risk	15	8	9	8
Family history	1	0	1	0
Ototoxic drugs	5	1	6	3
PIVH I	2	1	2	0
ICU for more than 5 days	10	9	10	6
Neonatal asphyxia	0	1	0	0

Note: PIVH I = peri intraventricular hemorrhage I; ICU = intensive care unit; AGA = adequate for gestational age; SGA = small for gestational age

DISCUSSION

The literature warns that SGA preterm or term newborns may have their neuro psychomotor development compromised for representing an early example of malnutrition[5,10,11]. According to the literature, the period and the duration of the condition are equally important. In the present study there were no statistically significant differences between symmetric and asymmetric SGA preterm infants with respect to the results obtained in ABR (Table 1). This finding is consistent with studies that performed the same comparison in term SGA newborns[22]. Few studies were found in the literature comparing AGA and SGA using methodology similar to the one applied in the present study.

The comparative analysis of ABR responses between SGA and AGA preterm newborns revealed that 32 infants presented alterations, although no significant difference was observed when comparing the groups (Table 2). This fact disagrees with a previous study that carried out the same analysis comparing SGA and AGA infants born at term, revealing a tendency to more alterations in the SGA group[22]. In contrast, the results obtained in the current study agree with those observed in a previous study in which the experimental group was composed by 28 SGA and compared to 28 AGA preterm newborns, with no differences between the groups. The authors concluded that premature infants with IUGR may suffer no harmful effects on the auditory pathway at the brainstem in the immediate neonatal period[23].

In the present study, a significant difference between genders in the AGA group was found – males exhibited more alterations than females – which did not occur in the SGA group (Table 3). These findings are similar to those obtained in a study with 86 term infants divided into SGA and AGA. In that study, a higher tendency to retrocochlear hearing disorders was observed in male newborns (75%) compared with female (32%) in the group AGA group. This, however, was not observed in the SGA group[22].

In the present study, the presentation speed of 27.7/s was applied, evidencing absolute and interpeak latencies slightly larger in comparison to a study with 86 children (of which 46 were in the neonatal period) that utilized a presentation speed of 21.1/s[8]. The same occurred with respect to other studies that used speed of stimulus presentation of 19/s and 10/s[23,24]. Such differences may be attributed to the parameters used to obtain the ABR. This fact agrees with previous studies[25,26] that found an increase in ABR absolute latencies and interpeaks with increasing speed of acoustic stimulus presentation.

The comparative analysis of absolute means of latencies of waves I, III, V and interpeaks I-III, III-V and I-V found in the current and the previously mentioned studies are described in Table 2.

With regard to ABR measures, the current study showed no differences between right and left ears (Table 4). These results differ from another study that investigated possible mechanisms of asymmetry in newborns through ABR revealing a right-ear advantage[27]. Thus, the results of the present study lead to the belief that the maturational process of auditory pathways simultaneously occurs in both ears, agreeing with studies that have also found no ear effects[8,22,28,29].

Evidences in the literature about the influence of risk factors when comparing preterm AGA and SGA newborns are not found. However, data from the present study indicate that, regardless of the appropriateness of weight, as well as the presence or absence of auditory risk factors, prematurity represents an aggravating risk factor due to complications surrounding and the need for care in the NICU (Chart 2). Such condition, and depending on the type of complications, may lead to ABR results suggestive of retrocochlear impairment. This fact agrees with a study that concluded that perinatal complications may adversely affect the most central auditory regions in the brainstem of preterm newborns in the NICU[30].

The present study found retrocochlear alterations, characterized by increased absolute latencies of waves III and/or V and interpeaks I-III and/or I-V, in 32 newborns. No significant differences between the SGA and AGA groups were observed. Some authors report that ABR results are influenced by auditory maturation and that their characteristics differ between infants who were born preterm and full-term due to the fact that myelination of the auditory pathway fibers is rostral-caudal[28-30].

Thus, it is believed that the alterations found in this study may be transient, suggesting monitoring of auditory development in this population. This agrees with previous studies that also recommended periodic audiologic evaluation with ABR in preterm and term infants with adequate weight and small for gestational age in order to obtain more reliable analyzes[22,28].

CONCLUSION

There was no difference between SGA and AGA preterm

Chart 2. Characterization of mean and standard deviation of ABR absolute latencies of waves I, III, V and interpeaks I-III, III-V, I-V reported in studies with preterm infants

Study	ABR Parameters	GA	n		I	III	V	I-III	III-V	I-V
Kohelet et al.[24]	*Click*: alternated *Rate*:10/s i: 75dBHL f: 100 Hz – 3 kHz	34	SGA=28	Mean (SD)	1.86 (0.19)	4.60 (0.39)	6.85 (0.39)	2.74 (0.29)	2.25 (0.35)	4.99 (0.33)
			AGA=28	Mean (SD)	1.78 (0.22)	4.44 (0.28)	6.82 (0.39)	2.66 (0.27)	2.38 (0.27)	5.04 (0.30)
Amorim et al.[8]	*Click:* rare *rate*: 21.1/s i: 80 dBHL f: 30 Hz – 3 kHz		12	Mean (SD)	1.80 (0.35)	4.47 (0.75)	6.66 (0.55)	2.66 (0.43)	2.19 (0.22)	4.85 (0.28)
Casali et al.[23]	*Click:* rare *rate*:19/s i: 80 dBHL f: 50 Hz – 3 kHz	35.7	30	Mean (SD)	1.70 (0.35)	4.14 (0.29)	6.42 (0.37)	2.53 (0.39)	2.28 (0.35)	4.71 (0.46)
Current study	*Click*: rare rate=27.7/s i: 80 dBHL f: 100 Hz – 1.5 kHz	30-36	SGA=35	Mean (SD)	1.85 (0.15)	4.76 (0.44)	7.23 (0.44)	2.93 (0.25)	2.48 (0.27)	5.38 (0.41)
			AGA=37	Mean (SD)	1.83 (0.14)	4.75 (0.36)	7.30 (0.38)	2.91 (0.35)	2.57 (0.58)	5.46 (0.43)

Note: GA = gestational age; rare = click with rarefied polarity; i = intensity; f = filters; SD = standard deviation; AGA = adequate for gestational age; SGA = small for gestational age

newborns in responses on the brainstem evoked auditory potential; the SGA condition was not revealed as a risk factor for retrocochlear alteration.

** RMGA was responsible for data collection and tabulation, and for manuscript elaboration; MFA supervised the findings and the elaboration of the manuscript; RMMC contributed with the technical review of the audiological procedures; AAF contributed with the statistical analysis of data; EMAD and RG were responsible for reviewing technical language and medical concepts; and CGM supervised the study and reviewed the manuscript.*

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