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Transient evoked otoacoustic emissions and auditory brainstem response in infants with perinatal asphyxia

Georgea Espindola Ribeiro [a, *], Daniela Polo Camargo da Silva [a], Jair Cortez Montovani [b]

[a] Botucatu Medical School, São Paulo State University (UNESP), Brazil

[b] Department of Ophthalmology, Otorhinolaryngology and Head and Neck Surgery, Botucatu Medical School, São Paulo State University (UNESP), Brazil

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ABSTRACT

Objective: The objective of this study was to verify the effects of perinatal asphyxia on different parts of the auditory system.
Methods: This was a non-concurrent cohort study conducted on a fixed population in a tertiary public hospital. Participants included 181 infants born at term who underwent the transient evoked otoacoustic emission test as a part of a neonatal hearing screening program, with a “pass” result in both ears, and by auditory brainstem response testing. The infants were divided into 3 groups: G1, 20 infants who had perinatal asphyxia; G2, 111 infants with an Apgar score lower than 4 in the first minute and/or lower than 6 in the fifth minute (called “low Apgar” at birth); and G3, 50 infants with first- and fifth-minute Apgar scores $\geq$7.
Results: The signal-to-noise ratio of transient evoked otoacoustic emissions were greater in G3 compared with G1 and G2 at 4 kHz frequency for males. An increased latency of waves I and III in the auditory brainstem response of male infants in G1 was observed.
Conclusion: This study demonstrated that alterations occurred in both the cochlear and the neural components in male infants who had perinatal asphyxia.

1. Introduction

Hearing is essential for language development. A prerequisite for hearing acquisition and development is the anatomical and physiological integrity of the neurologic and auditory system [1,2].

Therefore, all neonates should undergo a hearing assessment soon after birth. Investigation of auditory abnormalities may allow early diagnosis and treatment to minimize impacts on language development [3,4].

Some events may increase the chances for hearing loss. One such risk indicator is perinatal asphyxia, which is defined as an injury experienced by the neonate when there is significant peripartum hypoperfusion and decreased oxygen delivery resulting from different etiologies [5,6].

Hearing tests currently conducted on newborns include transient evoked otoacoustic emissions (TEOAE) and auditory brainstem response (ABR). The first evaluates the integrity of the outer hair cells (OHC) [7,8]. The second checks the integrity of the auditory pathway and estimates the auditory threshold [9].

Infants with risk indicators for hearing loss have more abnormal results in those tests. Studies in neonates with perinatal asphyxia demonstrate that hearing loss may occur in an isolated manner, at cochlear as well as neural portions. Many authors have demonstrated that these effects may be transient [10]. Detailed investigation of these structures in the newborn population enables further understanding of the true damage caused by this injury.

The objective of the study was to verify the effect of perinatal asphyxia in different parts of the auditory system.

2. Methods

The Ethics Committee of the hospital approved this study (process number 156/2012).

Data were collected from January 2014 to December 2015.

This was a non-concurrent cohort study on fixed population; therefore, exclusion criteria were not required. The inclusion criteria were: a) having been born in the hospital of the study; b)

* Corresponding author. Department of Ophthalmology, Otorhinolaryngology and Head and Neck Surgery, Botucatu Medical School, São Paulo State University (UNESP), Distrito de Rubião Junior s/n, 18618-970, Brazil.

E-mail address: georgea_espindola@hotmail.com (G.E. Ribeiro).

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Table 1
Population characteristics.

Group/Variables	G1(n = 20)	G2 (n = 111)	G3 (n = 50)
Female/Male	8(40%)/12(60%)	38(34%)/73(66%)	26(52%)/24(48%)
Gestational age[a]	39 (37–42)	39 (37–42)	38 (37–41)
Birth weight[a]	3315 (2630 4950)	3250 (2520–4465)	3302 (2555–4190)

[a] Summary as mean (minimum and maximum) gestational age and weight at birth.

gestational age ≥37 weeks; c) normal external auditory canal and tympanic membrane, as assessed by an ENT physician specializing in child hearing loss; d) a "pass" response in both ears on the TEOAE test, and ABR with all components identified; e) informed consent signed by the parents.

The population was divided into three groups:

- Group 1 (G1, n = 20), infants with a medical diagnosis of asphyxia who presented with at least two of the following parameters: pH ≤ 7.20 in the umbilical vein; Apgar score ≤ 6 at the fifth minute; and fraction of inspired oxygen ≥ 0.4 needed to achieve oxygen saturation ≥ 86% at birth [11].
- Group 2 (G2, n = 111), infants with an Apgar score < 4 in the first minute and/or < 6 in the fifth minute (called "low Apgar").
- Group 3 (G3, n = 50), infants with first- and fifth-minute Apgar scores > 7 ("control").

The TEOAE tests were performed with OtoRead (Interacoustics), a portable otoacoustic emissions instrument used in hearing screening programs. To obtain the responses the probe was coupled to the external ears of the newborn, preferably during the neonate's physiological sleep or when he or she was calm and in a quiet room. All neonates were evaluated after the 48th hour of life.

For analysis, the parameter "pass/refer" was used, as described in the equipment instructions. Click stimulus, intensity 83 dB sound pressure level (SPL), and six frequency bands were evaluated (1.5; 2; 2.5; 3; 3.5 and 4 kHz). Parameters related to whole wave reproducibility and total echo power are established into the equipment, and only perfect evaluation may achieve a "PASS" result. Values considered as PASS were: emissions present with a signal-to-noise ratio of 6 dB in at least three consecutive frequency bands, including 4 kHz.

The ABR test was conducted at one month of age, using the EP15 system (Eclipse/Interacoustics) in a quiet room. After cleaning the skin with an abrasive product, positive surface electrodes (Neuroline) were fixed to the Fz, and negative surface electrodes were fixed to M1 and M2. The ground lead was placed on Fpz. The stimulus was presented by means of an insertion phone (ER 3A), with monoaural stimulation, using filtered clicks (between 0.1 and 3 kHz) lasting 100 μs, rarefied polarity, at an intensity of 80 dB NPS. 1024 clicks were provided, at a presentation rate of 20.1 clicks/second, with an analysis time of 15 ms, and were repeated to confirm wave reproduction. Electrode impedance was maintained below 5 Kohms.

The groups were compared in relation to gender-stratified results using the non-parametric Kruskal-Wallis test, followed by the Dunn test for multiple comparisons. Normal distribution of the outcomes was rejected using the Shapiro-Wilk test. Differences were considered statistically significant when $p < 0.05$. Analysis was performed using SPSS v21.0 software.

With regard to sample size, considering an error type I = 0.05, the absence of confounding factors and the symmetry of results, our estimates indicate that the test power may be less than 0.8.

3. Results

Population data characteristics are described in Table 1.

In our first analysis, we observed that gender influenced the TEOAE and ABR results. To better address the research question, we separated our data by gender.

When comparing the TEOAE signal-to-noise ratio, we observed no significant differences between the groups of females. In males, however, the signal-to-noise ratios were greater in G3 as compared to G1 and G2 at the 4 kHz frequency, in both ears (Tables 2 and 3).

Furthermore we observed no differences when comparing ABR's absolute and interpeak latencies in the female groups, but we found increased absolute latencies for waves I and III in G1 male infants, in both ears, using the Kruskal-Wallis test. However, when we applied the Dunn test to differentiate the groups, we found no statistical differences in the analysis of wave III for the left ear (Tables 4 and 5).

4. Discussion

This study aimed to verify the effects of perinatal asphyxia in different parts of the auditory system, specifically, in the cochlea as well as in the auditory pathway.

In this study, newborn hearing assessments were performed twice; the first was conducted by TEOAE at 48 h following birth, and the second was conducted by ABR at one month of age. The time between the tests was necessary because they are performed in different sites. The TEOAE was performed in the nursery, and the ABR was performed in the hospital diagnostic center. However, all of the newborns included in the study had normal external auditory canals and tympanic membranes, as assessed by an ENT physician specializing in child hearing loss prior to both evaluations.

Another observation concerns the numbers of subjects in the different groups. We had a greater number of newborns with only a low Apgar score (G2) and fewer with asphyxia (G1) because it is a normal occurrence in the sample. We included 50 newborns in the control group, representing all of the infants whose parents agreed to participate in the research during the recruitment period.

The criteria used to characterize the TEOAE findings usually are based on a "pass/refer" response [12]. However, analysis of the

Table 2
Comparison between groups in relation to the response signal to noise ratio of TEOAE in female infants.

		G1 (n = 8)			G2 (n = 38)			G3 (n = 26)			*P*
		Med	Min	Max	Med	Min	Max	Med	Min	Max	
Right ear	3.0 kHz	9.5	6.0	19.0	12.0	6.0	23.0	12.5	6.0	25.0	*0.131*
	3.5 kHz	13.5	7.0	25.0	14.5	6.0	25.0	16.0	6.0	25.0	*0.861*
	4.0 kHz	13.5	7.0	25.0	14.5	6.0	25.0	13.5	6.0	27.0	*0.916*
Left ear	3.0 kHz	7.5	6.0	19.0	10.5	6.0	25.0	18.5	6.0	27.0	*0.135*
	3.5 kHz	14.5	6.0	30.0	14.0	6.0	27.0	17.0	6.0	25.0	*0.701*
	4.0 kHz	15.5	6.0	23.0	14.0	6.0	27.0	16.5	6.0	27.0	*0.677*

Med: median, Min: minimum, Max: maximum, ($p < 0.05$; Kruskal-Wallis test).