AIR AND BONE-CONDUCTION FREQUENCY-SPECIFIC AUDITORY BRAINSTEM RESPONSE IN NEONATES WITH NORMAL HEARING

Potencial evocado auditivo de tronco encefálico por frequência específica por via aérea e via óssea em neonatos ouvintes normais

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ABSTRACT

Purpose: to determine the minimum response and the latency of V wave in the Frequency-specific auditory brainstem responses (FS-ABR) in normal hearing neonates at the frequencies: 0.5, 1, 2 and 4 kHz by air and bone conduction and to determine normative values. **Methods:** normal hearing neonates were assessed with FS-ABR at 0.5, 1, 2 and 4 kHz, air and bone conduction. Twelve ears were assessed in each frequency, totalizing 18 neonates. Results analysis considered the latency and the presence of wave V until 20 dB nHL in air and bone conduction, for four intensities. **Results:** it was observed an increase of wave V latency with the decrease of intensity, and greater latencies at lower frequencies in both air and bone conduction. Nevertheless, there was no difference between the latencies at 0.5 and 1 kHz with strong intensity stimuli in both conditions, contrasting to literature findings. Considering air conduction, wave V was present at 0,5 kHz at 30 dB nHL in all ears and at 1 kHz 11 ears (91,66%) presented it at 20 dB nHL. All subjects (100%) presented responses to the other frequencies at 20 dBn HL. Considering bone conduction, all subjects presented wave V at 20 dB nHL in all frequencies. **Conclusion:** the found values can be used in clinical practice in order to guide the differential diagnosis of hearing loss, complementing the evaluation as for hearing neonates.

KEYWORDS: Audiometry, Evoked Response; Infant, Newborn; Hearing

INTRODUCTION

The early identification of congenital hearing loss and its proper rehabilitation provide great benefits for the child with hearing loss with regards to the development of speech perception, hearing abilities, communication, and language. Moreover, important gains can be observed in social interactions with family[1].

Hence, the audiological diagnosis must be carried out as soon as possible, so intervention can be initiated in the ideal period of neuroplasticity of the auditory nervous system. Electrophysiological hearing measures are used for this diagnosis, especially the auditory brainstem response test (ABR)[2,3]. The ABR may be evoked by acoustic stimuli presented both by air conduction (AC) or bone conduction (BC), and thus it may accurately provide the type and degree of the hearing loss[4].

Since the 70s, the click is the type of stimulus initially used in the ABR test for audiological diagnosis of newborns and infants[5]. Currently, in international protocols, the click is used only to verify the integrity of auditory pathways, assessing the synchrony of the neuronal function of the cranial nerve pair VIII and the brainstem auditory pathways, since it does

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not present frequency specificity. A study conducted in 2011 have described that the click represents the frequency between 500 and 8000 Hz with better threshold. Hence, this stimulus should not be used in clinical routine to estimate the hearing thresholds[6]. There are few assessment procedures that accurately diagnose hearing loss in children that are still not able to respond to the behavioral evaluation with conditioned procedures. Currently, the ABR with frequency-specific stimuli (FS-ABR), also known as tone burst ABR, is the most recommended method to obtain hearing thresholds in children younger than six months, according to the Joint Committee on Infant Hearing[7].

The tone burst stimulus is a short-duration sine wave, characterized by a frequency spectrum with energy centered in the stimulation frequency, more safely predicting the audiometric degree and configuration. Moreover, The FS-ABR can be conducted both by AC and BC[8].

There is strong evidence that, when the assessment protocol is adequate, the minimum response level (MRL) of the FS-ABR carried out by AC may predict the thresholds of conventional audiometry with good accuracy for a great variability of hearing loss configurations in both children and adults[3,6]. There is still little evidence for the estimate accuracy of hearing thresholds by BC; however, the Ontario Infant Program (IHP)[9] indicates that bone-conduction FS-ABR might provide useful information, differentiating conductive, mixed, and sensorineural hearing losses[10]. Few studies have conducted the standardization of the MRL and latency measures of wave V measures obtained by BC. The main frequencies studied are 500 and 2000 Hz, while there are no standards regarding the frequencies of 1000 and 4000 Hz for infants.

A study conducted in Canada presented evidences that the FS-ABR might estimate different degrees and configurations of hearing loss. Thus, this method – by both AC and BC – may be considered the most adequate for the assessment of children, since it allows an accurate diagnosis of the hearing loss. It is known that a precise audiological profile allows that children receive the benefits from the use of hearing aid devices and early and more effective appropriate rehabilitation procedures, reducing the damage caused by sensory deprivation[11].

The aims of this study were to determine the minimum response levels (MRL) of the FS-ABR and wave V latency obtained by air and bone conduction in normal hearing newborns, for the frequencies of 0.5, 1, 2 and 4 kHz, and to determine standard values for these measures.

METHODS

The present research was carried out at a high-complexity reference service in hearing health in the city of São Paulo, Brazil. The study was approved by the Research Ethics Committee of the institution, under protocol number 134/2010. The parents or legal guardians of the children selected for the study signed a Free and Informed Consent Form.

This is characterized as a quantitative and qualitative cross-sectional descriptive study.

Participants were newborns with normal hearing, referred from a state hospital in the city of São Paulo for Newborn Hearing Screening (NHS), since the test is not available at the hospital before discharge. The newborns were referred by the neonatologist of the hospital, with previous scheduling at the high-complexity reference service. After the NHS was carried out, the caregivers of the newborns with satisfactory results, that is, those who passed the screening, were invited to participate in the study.

It was defined the need for twelve ears – six right ears and six left ears. This number was enough for data collection, since there is no significant variability between subjects in the ABR recording. The frequencies of 500, 1000, 2000 and 4000 Hz were assessed, and 18 newborns participated in the study.

The inclusion criteria for this study were: full-term and preterm newborns with corrected gestational age (CGA) over 39 weeks who had passed the NHS using the click ABR method in the intensity of 35 dbnHL; to present tympanometry curve type A[12] with 226 and 1000 Hz probe tones; absence of suspected or diagnosed déficits, such as visual, neurological or psychological/psychiatric alterations.

Each subject was assessed through the FS-ABR for the frequencies of 500, 1000, 2000 and 4000 Hz. Only one or two frequencies were recorded for each newborn, in both ears, for both AC and BC. This option was due to the time needed for each recording, which was carried out during natural sleep.

The FS-ABR recording was carried out in an acoustically treated room using the equipment Eclipse Black Box – software EP25, from Interacoustics MedPC, calibrated according to the standard ISO-389-6 (International Organization for Standardization – ISO)[13]. Tone burst is the stimulus used in this equipment for FS-ABR recording.

The newborns were in natural sleep in their caregivers laps during the assessment. When the child woke up or was in restless sleep, the assessment was interrupted until the ideal sleep condition was obtained for resuming.

For the placement of electrodes, the infants's skin was cleaned with alcohol and abrasive paste Nuprep, in order to remove the oiliness – which may interfere in the capture of responses for the test. The electrodes were placed as it follows: reference electrodes in the right (M2) and left (M1) mastoids, and active (Fz) and ground (Fpz) electrodes in the forehead. The impedance of electrodes was equal to or lower than 3 kΩ for recording.

The wave V threshold was searched using the descending technique by 20 dB steps. In the absence of the recording of wave V, the intensity level was increased by 10 dB steps. Intensity levels below 20 dB were not assessed, because this is internationally considered a normal hearing level[10,11,14].

To record the air-conduction FS-ABR, insert earphones EARTONE 3A were placed in the infants' external auditory canal. The assessment was initiated at 80 dBnHL.

To record the bone-conduction FS-ABR, the bone conduction transducer Radioear B-71 was placed in the skull above the M1 electrode (when the left ear was tested) and the M2 electrode (when the right ear was tested). The vibrator was fixed with a self-adherent elastic wrap (Coban, model 1582, from 3M, with 5 cm width) with force of 400±25 g, measured by a Ohaus-Spring scale, model 8264-M. The initial intensity level for the BC assessment varied between 40 and 50 dBnHL, depending on the presence of artifacts during recording, which may be present when a bone transducer is used.

Wave V is defined as the higher positive vertex, followed by a long negative deflection, and its threshold was determined by the lower intensity in which the wave was identified[11]. The recording was carried out twice in each intensity level, in order to verify the reproducibility of the responses. At least 800 stimuli with residual noise below 0.04 μV were used, according to the parameters recommended by the manufacturer.

Figure 1 describes the stimuli characteristics for the FS-ABR assessement, both by AC and BC.

	Frequencies			
	500 Hz	**1000 Hz**	**2000 Hz**	**4000 Hz**
Polarity	Alternate	Alternate	Alternate	Alternate
Analysis window	24 ms	24 ms	24 ms	24 ms
Duration of stimulus	6 ms	5 ms	2.5 ms	1.25 ms
Cycles	3	5	5	5
Envelope	*Blackman*	*Blackman*	*Blackman*	*Blackman*
Repetition rates	27.1/s	27.1/s	27.1/s	27.1/s
Filters	100-3000Hz	100-3000Hz	100-3000 Hz	100-3000Hz

Figure 1- Characteristics of the stimuli used in FS-ABR recording

For data analysis, descriptive statistic measures were conducted, analyzing the latencies in the four frequencies studied, for the different intensity levels. Moreover, for latencies times, 95% confidence levels were considered, using the t-Student distribution.

The analysis of minimum response levels did not consider inferential statistical analyses because there was no significant variation between subjects; hence, the analyses were merely descriptive. Nevertheless, to determine the relationship between latency and intensity for each frequency, growth curves were estimated, describing the behavior of latency as a function of intensity. The adjusted curve model was given by[15]:

Air conduction:

- **Frequency of 500 Hz:** Expected latency = $18.955 - 0.203 \times \text{Intensity} + 0.0009 \times \text{Intensity}^2$.
- **Frequency of 1000 Hz:** Expected latency = $13.670 - 0.064 \times \text{Intensity}$.
- **Frequency of 2000 Hz:** Expected latency = $11.874 - 0.077 \times \text{Intensity} + 0.0003 \times \text{Intensity}^2$.
- **Frequency of 4000 Hz:** Expected latency = $9.867 - 0.038 \times \text{Intensity}$.

Bone conduction:

- **Frequency of 500 Hz:** Expected latency = $15.696 - 0.122 \times \text{Intensity}$.
- **Frequency of 1000 Hz:** Expected latency = $13.846 - 0.069 \times \text{Intensity}$.
- **Frequency of 2000 Hz:** Expected latency = $13.328 - 0.094 \times \text{Intensity}$.
- **Frequency of 4000 Hz:** Expected latency = $9.941 - 0.053 \times \text{Intensity}$.

RESULTS

Initially, the group was characterized regarding the corrected gestational age (CGA) of the newborns, by adding the weeks of life to the gestational age, for each frequency assessed (Table 1).

Below, we present the results of the FS-ABR, according to the presence of wave V until the intensity of 20 dBnHL and the respective latency times found, both by AC and BC.

Table 2 shows the minimum intensity level in which wave V was observed in each frequency. In the frequency of 500 Hz by AC, all 12 ears presented wave V only at 30 dBnHL. In the frequency of 1000 Hz, 11 ears (91.66%) presented responses at 20 dB, and only one (8.34%), at 30 dBnHL. The other frequencies assessed by AC and all frequencies assessed by BC presented responses at 20 dBnHL, in 100% of the ears evaluated.

Table 1 - Descriptive statistics of the corrected gestational ages (weeks) of the newborns for each frequency assessed (n=12 ears)

	Corrected Gestational Age (weeks)			
	500Hz	**1000Hz**	**2000Hz**	**4000Hz**
Mean	44.17	42.33	41.00	42.71
Median	43.00	42.00	40.50	42.00
Standard Deviation	3.13	2.42	2.10	2.93

Table 2 - Minimum intensity levels (dBnHL) in which wave V was observed in the frequencies of 500, 1000, 2000 and 4000 Hz by air and bone conduction, obtained in the Frequency-Specific Auditory Brainstem Response (n=12 ears for each frequency)

	Wave V presence until 20 dBnHL			
	500Hz	**1000Hz**	**2000Hz**	**4000Hz**
Air conduction	30 dBnNA (100%)	20 dBnNA (91,66%)	20 dBnNA (100%)	20 dBnNA (100%)
Bone conduction	20 dBnNA (100%)	20 dBnNA (100%)	20 dBnNA (100%)	20 dBnNA (100%)

The following tables present descriptive statistics of the latency times of wave V and the 95% confidence intervals for the intensities and frequencies studied, both by AC (Table 3) and BC (Table 4).

Adjusted growth curves of latency as a function of intensity in all four frequencies were determined for both AC and BC, and are presented in Figures 2 and 3.

It was observed that in the maximum intensity assessed, both by AC and BC, the latency was longer for lower frequencies, decreasing as frequency increased.

In the frequencies of 500 and 1000 Hz, there was minimum variation in latency at 80 and 60 dBnHL; however, with intensity decrease, this difference was more evident.

Table 3 - Descriptive statistics and 95% confidence interval for wave V latency time (ms) at each intensity level by air conduction, in the frequencies of 500, 1000, 2000 and 4000 Hz, obtained in the Frequency-Specific Auditory Brainstem Response (n=12 ears for each frequency)

Intensity dBnHL	500Hz		1000 Hz		2000 Hz		4000 Hz	
80	Mean	8.53	Mean	8.61	Mean	7.75	Mean	6.91
	Median	8.53	Median	8.77	Median	7.64	Median	7.00
	SD	0.17	SD	0.38	SD	0.29	SD	0.38
	IL	8.42	IL	8.37	IL	7.57	IL	6.67
	SL	8.64	SL	8.86	SL	7.93	SL	7.16
60	Mean	10.11	Mean	9.76	Mean	7.75	Mean	7.49
	Median	10.13	Median	9.74	Median	7.64	Median	7.60
	SD	0.55	SD	0.49	SD	0.29	SD	0.38
	IL	9.75	IL	9.26	IL	8.11	IL	7.24
	SL	10.46	SL	9.78	SL	8.58	SL	7.73
40	Mean	12.22	Mean	10.95	Mean	9.34	Mean	8.22
	Median	12.17	Median	10.97	Median	9.40	Median	8.27
	SD	0.55	SD	0.47	SD	0.24	SD	0.45
	IL	11.87	IL	10.62	IL	9.18	IL	7.93
	SL	12.57	SL	11.04	SL	9.49	SL	8.50
30	Mean	13.73	Mean	12.35	----	----	----	----
	Median	13.51	Median	12.20	----	----	----	----
	SD	0.57	SD	0.33	----	----	----	----
	IL	13.36	IL	11.53	----	----	----	----
	SL	14.09	SL	13.40	----	----	----	----
20	----	----	Mean	12.50	Mean	10.44	Mean	7.49
	----	----	Median	12.47	Median	10.47	Median	7.60
	----	----	SD	1.18	SD	0.38	SD	0.38
	----	----	IL	11.79	IL	10.20	IL	8.86
	----	----	SL	12.67	SL	10.68	SL	9.57

SD – standard deviation; IL – inferior limit; LS – superior limit; ---- - not conducted

Table 4 - Descriptive statistics and 95% confidence interval for wave V latency time (ms) at each intensity level by bone conduction, in the frequencies of 500, 1000, 2000 and 4000 Hz, obtained in the Frequency-Specific Auditory Brainstem Response (n=12 ears for each frequency)

Intensity dBnHL	500Hz		1000 Hz		2000 Hz		4000 Hz	
50	----	----	Mean	9.72	----	----	----	----
	----	----	Median	9.74	----	----	----	----
	----	----	SD	0.47	----	----	----	----
	----	----	IL	8.97	----	----	----	----
	----	----	SL	10.46	----	----	----	----
40	Mean	10.89	Mean	11.07	Mean	9.61	Mean	7.84
	Median	10.97	Median	11.04	Median	9.47	Median	8.00
	SD	0.96	SD	0.74	SD	0.53	SD	0.59
	IL	10.28	IL	10.60	IL	9.27	IL	7.47
	SL	11.50	SL	11.54	SL	9.94	SL	8.21
30	Mean	11.91	----	----	Mean	10.48	----	----
	Median	11.87	----	----	Median	10.27	----	----
	SD	1.21	----	----	SD	0.97	----	----
	IL	10.90	----	----	IL	9.86	----	----
	SL	12.92	----	----	SL	11.10	----	----
20	Mean	13.33	Mean	12.46	Mean	11.48	Mean	8.89
	Median	13.30	Median	12.10	Median	11.27	Median	9.07
	SD	1.05	SD	1.03	SD	1.00	SD	0.43
	IL	12.66	IL	11.80	IL	10.84	IL	8.62
	SL	14.00	SL	13.11	SL	12.12	SL	9.16

SD – standard deviation; IL – inferior limit; LS – superior limit; ---- - not conducted

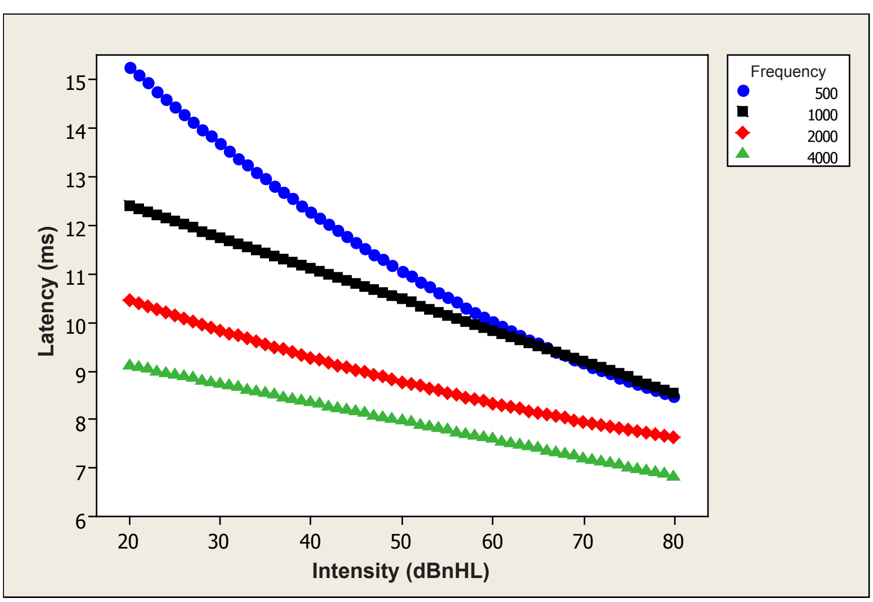

Figure 2 - Adjusted wave V latency curves x intensity levels obtained in the four frequencies assessed by air conduction (n=12 ears in each frequency)

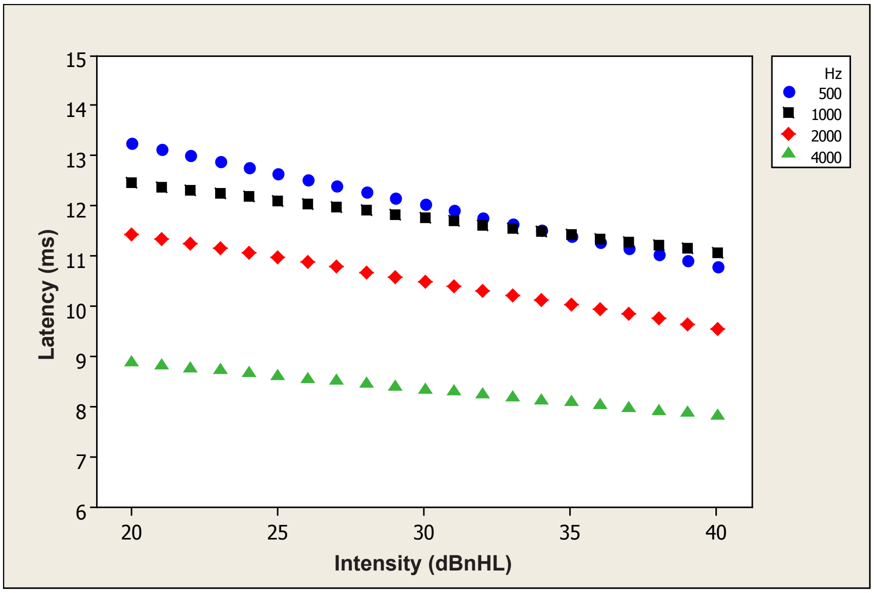

Figure 3 - Adjusted wave V latency curves x intensity levels obtained in the four frequencies assessed by bone conduction (n=12 ears in each frequency)

DISCUSSION

The standardization of the MRL (electrophysiological threshold) and latency values in different age ranges are essential for the clinical use of ABR. It is also essentially important for FS-ABR, especially in newborns and young children, because this is a resource that, along with the Evoked Otoacoustic Emissions and Tympanometry, defines configuration, degree, and type of hearing loss.

Thus, to define the reference parameters, that is, the values considered normal, for clinical interpretation of FS-ABR results in audiological diagnosis, this study assessed newborns with normal hearing. The presence of wave V was determined until the intensity of 20 dBnHL, and the latency values were obtained as a function of intensity. The results obtained for the four frequencies studied (500, 1000, 2000 and 4000 Hz) are discussed below.

Presence of wave V

Air conduction

Regarding the intensity taken to visualize wave V in the **frequency of 500 Hz**, all the ears assessed obtained responses only until 30 dBnHL by AC. This finding corroborate several studies[14,16-20], in which the mean MRL were different from the present study by less than 10 dB. A meta-analysis and a study conducted in 2007 both showed lower MRL – 19.6 and 18.4 dBnHL, respectively[11,21]. Hence, the authors of the latest research suggested that the intensity of 30 dBnHL should be considered as standard for this frequency[21]. The MRL of 500 Hz are always higher when compared to the other frequencies; however, it is known that the morphology of wave V for this frequency is not as well defined, besides being more influenced by noise, which can cause interference in the visualization of responses at lower intensities[20,22].

In the **frequency of 1000 Hz**, only one ear presented responses at 30 dBnHL; there were responses in the other 11 ears (91.66%) at 20 dBnHL. In literatures, the MRL varied in this frequency. Some studies[10,19,21] have observed MRL lower than 20 dBnHL while others have found MRL between 25 and 35 dBnHL for this frequency[20,23]. In the present research, the minimum intensity considered was 20 dBnHL.

In the **frequency of 2000 Hz**, there were well defined responses at the minimum intensity considered (20 dBnHL) in all ears. Some studies have found MRL below 20 dBnHL[10,14,19-21]. A Brazilian study from 2009 found a mean MRL of 32.5 dBnHL in the right ear, and 32.2 dBnHL in the left ear. The author believes these results are due to methodological differences, such as: lack of experienced judges in noting wave V, use of few stimuli, and use of supra-aural earphones, instead of insert earphones, as in most studies[24].

In the **frequency of 4000 Hz**, as in 2000 Hz, there were responses at 20 dBnHL in all ears. This frequency was recently recommended by Stevens to initiate the audiological diagnosis through FS-ABR[25]. The MRL cited in literature for this frequency suggest responses at intensities lower than 20 dBnHL[10,14,19-22]. However, in the present research, the newborns were in natural sleep and not sedated, as in some o these previous studies, which justified the option for the minimum intensity level of 20 dBnHL, as previously described in the methods.

Although estimating the electrophysiological threshold is a procedure that takes time, especially in lower frequencies – that are usually affected by noise and do not have well defined wave V morphology –, the results of the present study were not different from literature findings and from what is suggested by international guidelines, showing that the use of air-conduction FS-ABR has great applicability.

Bone conduction

In **500 Hz**, responses were present in all ears at 20 dBnHL in the bone conduction condition, as suggested by internacional studies and programs, which have established this intensity as standard parameter[3,14,26]. In another study[27], there were responses at 30 dBnHL for 100% of the subjects, and at 20 dBnHL for 80%. Authors have emphasized that it is more difficult to detect wave V in this frequency, when compared to 2000 Hz, because it is morphologically more rounded. These authors also highlight that the bone-conduction MRL in children might be higher, since the anatomy of an adult skull has more mass and, hence, a thicker temporal bone[28].

A study carried out in 1997 emphasized that the FS-ABR recording by BC in 500 Hz is essential to establish the presence of conductive factors, since this frequency is the most affected by the presence of fluids in the middle ear[29].

We found only two studies that assessed the **frequency of 1000 Hz** by bone conduction. In the present research, well-defined responses were obtained in 1000 Hz at 20 dBnHL in all ears evaluated, showing linearity in the results. A study from 1993 assessed this frequency by BC and found FS-ABR results between 10 and 20 dB higher than those obtained in behavioral audiometry[30].

In this study, wave V was recorded at 20 dBnHL in the **frequency of 2000 Hz** in all ears tested. An international study found that 94% of their subjects presented responses at 30 dBnHL[26]. For the authors of that study[26], as well as for other authors[3,27], the intensity of 30 dBnHL might suggest normal cochlear sensitivity. A research conducted in 1993 found mean MRL of 8.46 and 13.75 dBnHL for adults and children, respectively[28].

An international guideline suggests the use of bone-conduction FS-ABR in the **frequency of 4000 Hz** for the audiological diagnosis of newborns, infants, and children; however there is little evidence in literature regarding FS-ABR in this frequency[25]. In the present study, wave V was recorded until the intensity of 20 dBnHL in all ears assessed. Authors have emphasized that the recording in 4000 Hz is important because it provides information about higher frequencies, which is useful for audiological diagnosis[29].

The results of the present study have shown that bone-conduction FS-ABR is viable in all four frequencies tested, adequately evaluating cochlear sensitivity. Moreover, the detection of wave V by bone conduction was not harder to obtain than in air conduction, even at lower intensities. The only limitation for bone conduction FS-ABR was the maximum intensity of the equipment, which varies from 50 to 40 dBnHL.

Function Latency X Intensity

Air conduction

Regarding the function latency X intensity, a latency increase was observed with the decrease of the intensity level used to trigger the response, as well as a latency decrease with the increase of the frequency assessed, as suggested in the literature[18,20,31].

In the present study, the function latency X intensity in the frequencies of 500 and 1000 Hz did not behave as shown in literature[18,20,31], since these frequencies were very similar at the intensities of 80 and 60 dBnHL. Nevertheless, some authors[14,32,33] have pointed out that, at higher intensities, a short stimulus, such as the tone burst, might evoke responses from adjacent areas in the cochlea, generating acoustic energy in frequencies that are not being assessed. Hence, there is not a specificity of stimulus frequency at higher intensities. This happens mainly at lower frequencies (below 2000 Hz), which may explain the findings of the present study. For this specificity to occur, these authors have suggested the use of ipsilateral masking, which restricts responses from areas of the basilar membrane that should not be stimulated[14,32,33].

For the **frequency of 500 Hz**, the mean latency found at 80 dBnHL was of 8.53±0.17 ms, and at 30 dBnHL, of 13.73±0.57 ms. Only one study assessed latency at 80 dBnHL[34], and the mean latency of wave V found was longer than in the present study (Full-term children: 11.0±0.7 ms; preterm children: 12.1±0.3 ms). At the intensity of 30 dBnHL, some studies have found mean latencies similar to those in the present study[18,20,35].

In the **frequency of 1000 Hz**, at 80 dBnHL, the latency time was 8.61±0.38 ms, shorter than the results of another study conducted in Brazil

(9.24±0.5 ms)[23]. At 60 dBnHL, the latency of wave V was very similar to the findings of two other studies[23,24]. At 20 dBnHL, the mean latency was 12.50±1.18 ms, which was similar to the mean latency found in another study at the intensity of 15 dBnHL (12.2±0.69 ms)[36].

The latencies obtained in the present research for the **frequency of 2000 Hz** were similar to those found in a Brazilian study[24] at all intensities. The mean latency at 20 dBnHL was 10.44±0.38 ms, corroborating the findings of other studies[19,20,22].

The latency times found in the present research for the **frequency of 4000 Hz** corroborate the findings of other authors at 20 dBnHL[18-20] and 60 dBnHL[19,36]. The latencies of wave V in a study conducted in 2010 were longer at all intensities when compared to the findings of this study and the other studies mentioned above. This difference may have occurred due to the use of different parameters[34].

Bone conduction

As in the air conduction condition, there was an increase in the latency of wave V with the decrease of intensity and frequency. Again, in the frequencies of 500 and 1000 Hz, in the higher intensity assessed, the latencies did not behave as expected, that is, there was little variation between these frequencies. On the contrary, other authors have observed that the latency of wave V is longer as lower the frequency studied[30]. The same explanation presented before for AC may fit the results obtained for BC: there is activation of adjacent areas of the cochlea at higher intensities, generating acoustic energy in frequencies that are not being assessed[16,32,33].

The latency times found in another study for the frequencies of 500 and 2000 Hz were similar to the findings of the present research, at all intensities[19]. For the frequencies of 1000 and 4000 Hz, we did not find studies that have analyzed the latency times of wave V.

It may be observed that there was little variation in the latency times between newborns, both in AC and BC conditions, since the standard deviation values obtained for all frequencies and intensities were small, showing linearity in the appearance of wave V.

It is worth mentioning that latency is affected by the parameters chosen for the assessment, as well as by the equipment used. For the BC condition, the placement and the strength of the bone vibrator may also alter the wave latency time. For this reason, the bone vibrator must be used always in the same position and with the same strength, in all subjects[37].

It is extremely important that the equipment is standardized according to the protocol chosen before the clinical use of FS-ABR by AC and BC, by testing children and adults and verifying whether the findings corroborate the literature, thus establishing the consistency of the equipment with the literature findings. By doing this, the evaluator may compare his clinical findings with the pre-established standardized parameters and determine the existence of a hearing alteration, classifying the degree and type of hearing loss.

CONCLUSIONS

Based on the results obtained, considering the parameters and recordings obtained in the equipment used, we conclude that:

Minimum response levels at 30 dBnHL for 500 Hz and 20 dBnHL for 1000, 2000 and 4000 Hz by AC and 20 dBnHL for 500, 1000, 2000 and 4000 Hz by BC may be considered normal, and used as standard parameters in clinical interpretation of FS-ABR in newborns.

The mean latency of wave V in the frequencies of 500, 1000, 2000 and 4000 Hz at 80 dBnHL were, respectively, 8.53, 8.61, 7.75, and 6.91 ms in the AC condition; in the BC condition, the mean latencies found were 10.99, 11.07, 9.61, and 7.84 ms, respectively for 500, 1000, 2000 and 4000 Hz. These latency values may be considered normal for the age range studied.

RESUMO

Objetivo: determinar os níveis mínimos de resposta (NMR) e a latência da onda V do Potencial Evocado Auditivo de Tronco encefálico por Frequência específica (PEATE-FE) em neonatos ouvintes normais nas frequências de 0.5, 1, 2 e 4 kHz por via aérea e via óssea e determinar valores normativos. **Métodos:** foram avaliados neonatos com audição normal, sendo realizado o PEATE-FE nas frequências de 0.5, 1, 2 e 4 kHz, tanto por via aérea (VA) quanto por via óssea (VO). Para cada frequência, foram avaliadas 12 orelhas em um total de 18 neonatos. A análise dos resultados avaliou o tempo de latência e a presença da onda V até a intensidade de 20 dBnNA para quatro intensidades e para os dois tipos de condução (aérea e óssea). **Resultados:** observou-se aumento da latência da onda V com a diminuição da intensidade e maiores latências nas frequências mais baixas, tanto na VA quanto na VO. Porém, em fortes intensidades, em ambas condições, não houve diferença entre as latências de 0.5 e 1 kHz, contrariando os achados da literatura. Para VA, na frequência de 500 Hz, houve presença da onda V até 30 dBnNA em todas as orelhas, e em 1000 Hz, 11 orelhas (91,66 %) apresentaram resposta em 20 dBnNA; nas demais frequências, 100% das orelhas avaliadas apresentaram resposta em 20 dBnNA. Na VO, a presença da onda V em 20 dBnNA foi observada em todas as frequências estudadas. **Conclusão:** os valores descritos podem ser considerados normativos e utilizados na clinica como padrão de normalidade, auxiliando no diagnóstico diferencial da perda auditiva ao nascimento.

DESCRITORES: Audiometria da Resposta Evocada; Neonato; Audição

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