THE USE OF BAND LIMITED STIMULUS IN NEWBORN HEARING SCREENING WITH AUTOMATED AUDITORY BRAINSTEM RESPONSES

A utilização de estímulos de banda limitada na triagem auditiva neonatal com o potencial evocado auditivo de tronco encefálico automático

Mabel Goncalves Almeida[(1)], Taise Argolo Sena[(2)], Isabela Freixo Côrtes Andrade[(2)], Milena Nóbrega Campos de Sousa[(2)], Dóris Ruthi Lewis[(3)]

ABSTRACT

Purpose: to study the results obtained in Automated Evoked Auditory Brainstem Response (A-ABR) with a frequency-specific chirp stimulus. **Methods:** the A-ABR with the stimulus HiLo CE-Chirp ®, the intensity of 35 dB NNA, was recorded in 50 newborns (NB) with and without risk factors for hearing loss and compared to the Frequency-specific ABR (FE-ABR). We analyzed the results "pass / fail" for the stimulus HiLo CE-Chirp ® and the components Hi and Lo, separately, and determined validation measures. The detection time of A_ABR was also determined. **Results:** A-ABR with HiLo CE-Chirp ® showed high failure (36%) and false positives rates (33%). Significant differences between the percentages of "failure" between the two components were observed, and the percentage of component failure greater than the Hi Lo, in both ears. The mean time to detection of response was 63.8 seconds for the right ear and 77.9 for the left ear, with statistically significant differences between the ears (p = 0.002). **Conclusion:** the band stimulus presented limited mean sensing response considerably small, high sensitivity, however, due to high rate of false positives, showed low specificity, there is a need for improvement in technique or stimulus for its future application clinical A-ABR.

KEYWORDS: Hearing Tests; Hearing; Infant, Newborn; Hearing Loss

INTRODUCTION

Hearing loss identification and diagnosis occurring as early as possible, followed by immediate intervention are among the decisive factors to minimize functional damages in language and speech development, since the central auditory system is highly plastic for a certain period of time[1].

Newborn hearing screening with automatic procedures currently uses broadband stimuli, such as the click, that stimulate practically the entire basilar membrane. Therefore, hearing losses in specific regions may be underestimated or even overestimated, due to the differences in audiometric configurations[2,3].

The need to improve the efficiency of hearing loss identification procedures and to minimize the number of false-positive and false-negative cases resulting mainly from mild hearing losses and losses in specific frequencies, has led to the development of new stimuli, including specific frequency stimuli.

(1) Universidade Federal do Espírito Santo – UFES, Brasil.

(2) Pontifícia Universidade Católica de São Paulo- PUCSP, São Paulo, SP, Brasil.

(3) Faculdade de Ciências Humanas e da Saúde da Pontifícia Universidade Católica de São Paulo - PUC-SP, São Paulo, SP, Brasil.

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Conflict of interest: non-existent

Initially, the scientific community turned its attention to studying the reliability of the broadband chirp stimulus in diagnostic [4-9] and automatic[10,11] procedures. This stimulus was built in order to try to compensate the time delay caused by the sound wave travelling along the basilar membrane through the promotion of the delay of high frequencies in relation to the low frequencies of the stimulus, thus producing simultaneous stimulation of all cochlear regions. The simultaneous stimulation of the cochlea provides an improvement in neural synchronicity and, consequently, an increase in the amplitude of wave V when compared to the click, especially in weak and moderate intensities[4,12,13] . The increase in amplitude leads to a decrease in the time of examination since it promotes an improvement in the signal-noise relationship, one of the main parameters for determining the presence of response[7].

The results obtained from the broadband chirp led the scientific community to develop and study, experimentally, specific frequency chirps. Studies with diagnostic procedures have shown that greater wave V amplitudes were obtained with the specific frequency chirp, when compared to those obtained using tone burst stimulus in adults[14]. Furthermore, low frequency chirps lead to a higher synchronicity of neural discharge, which reflects in greater amplitude, especially in weak and moderate intensities[15]. Studies using the Auditory Steady-State Response (ASSR) that used specific frequency chirps named *narrow band CE-chirps®* have also shown large wave V amplitudes with decrease in examination time [5-7]. Shorter latencies and greater amplitudes (wave V) for chirp, especially in weaker intensities (20-40 dB HL) were also reported by a national study when comparing results from the toneburst evoked auditory brainstem response (TB-ABR) and n*arrow band CE-chirps®* of normal hearing children[8].

The application of band-limited chirps or specific frequency band stimuli has also proven promising in procedures of Newborn Hearing Screening (NHS) [13].

One of the first studies using a band-limited stimulus in hearing screening procedure was conducted in 2007, and showed that this technique may be used, but should be improved[13]. To the present moment, there have been few studies showing results about the usage of specific frequency stimuli in NHS.

In this same context, the improvement of technologies related to auditory rehabilitation reinforces the need for development and improvement of procedures that are capable of identifying all hearing loss configurations at birth, which can only occur using specific frequency stimuli.

Thus, the purpose of the present paper was to study the results obtained in a NHS using automated auditory brainstem response (AABR) with band-limited chirp stimulus.

METHODS

This is a descriptive-analytical, quantitative, cross-sectional and experimental research. The present study was approved by the research ethics committee under protocol number 118/2011.

In order to be included in the study, the newborns could not have any suspicion of neurological disorders and/or syndromes suggested on their records, outer ear or ear canal agenesis and should be more than 24 hours old with gestational age equal to or greater than 37 weeks. The newborns who either passed or refered hearing screening by Transient Otoacoustic Emissions (TOAE) and/or click-AABR, conducted by the hospital NHS, with or without risk indicators for hearing loss were included in the study.

The research medical record was performed first, followed by electrophysiological procedures: AABR with a Hi-Lo CE-Chirp® stimulus, Click-ABR and TB-ABR to 500 Hz and 2 kHz stimuli.

The TB-ABR was used as the gold standard in order to ensure and to verify the sensitivity and specificity of the responses obtained by the AABR. The equipment used was the Interacoustics MedPC Eclipse Black Box – software EP25.

The greatest deflection occurring between 5 and 20ms after stimulus presentation was considered the V wave. The lowest threshold level researched was 20 dBnHL. For the TB-ABR to 500Hz, the air conduction (AC) record was taken in intensities of 60, 30 and 80 dBnHL, in this sequence. For the TB-ABR to 2 kHz, AC was conducted in intensities 40, 20 and 80 dBnHL, in this sequence. Bone Conduction (BC) research was performed in 40 and 20 dBnHL, in this sequence, at 500 Hz and 2 kHz. In the case of absence of response in one of the evaluated intensities, the intensity was increased in steps of 5dB in AC and 10dB in BC until wave V was able to be identified and reproduced. The maximum intensity researched for AC was 100dBnHL and 50dBnHL for BC.

For TB-ABR at 500 Hz the intensity of 35 dBnHL and 20 dBnHL was considered as the normal pattern for AC and BC, respectively. The intensity of 30 dBnHL was considered the normal pattern for AC and 30dBnHL for BC on the 2kHz, according to the *British Columbia EarlyHearingProgram*- BCEHP (2008) protocol[16].

The NHS with AABR was conducted with the *Hi-Lo CE-Chirp®* stimulus in 35dBnHL intensity.

The *Hi-Lo CE-Chirp*® stimulus is composed by two frequency ranges: the range containing the high frequency spectrum, between 1414 and 11313 Hz, named *Hi* and the range containing the low frequency spectrum between 177 and 1414 Hz, called *Lo*. Both ranges were presented simultaneously and separated by a cut-off frequency of 1500 Hz. The stimulus was presented at a 90Hz repetition rate in alternate polarity. The maximum time established for the determining the presence/absence of response in the AABR was 180 seconds. The *interacoustics* Titan software *ABRIS440* was the equipment used for testing.

The newborns with abnormal gold standard results were submitted once again to hearing screening by Transient Otoacoustic Emissions (TOAE) using an otodynamics otoport Lite equipment with 84dBSPL intensity and non-linear click stimulus.

All procedures were conducted at the maternity Ward, before hospital discharge.

There was no order observed for procedure conduction, and all procedures were completed in both ears.

All newborns with altered results in the TB-ABR were referred for audiological diagnosis at a high complexity reference center.

Data analysis

A descriptive analysis of AABR results (Pass/Refer) with *Hi-Lo CE-chirp*® stimulus and for *Hi* and *Lo* components, separately, in 35 dBnHL intensity was conducted. Independence among the results of both ears was assessed using the Qui-square test for the results obtained from the *Hi-Lo CE-chirp*® stimulus; for the *Hi-Lo* components, Fisher's exact test was used (Fisher and van Belle, 1993).

Result analysis considered the existence of three different tests: the "*Hi-Lo Test"* when results referred to the final (Pass/Refer) result, the "*Hi* Test" when the (Pass/Refer) results were analyzed only for the *Hi* component of the *Hi-Lo CE-chirp*® stimulus, and the "*Lo* Test" when the (Pass/Refer) results were only analyzed for the *Lo* component.

Diagnostic skill measures (sensitivity, specificity, PPV, NPV), Youden index and the Kappa coefficient were determined. In this study, the diagnostic skill measures were determined considering the gold standard (frequency-specific-ABR with tone bursts stimuli) normal when the BC threshold level for the frequencies of 500 Hz and 2 kHz were less than 20 and 30 dBnHL, respectively. Therefore, the gold standard was considered altered when the threshold level for AC and BC in 500 Hz and/or 2kHz were not within the established normal patterns.

The agreement between the results obtained for the AABR (Pass/Refer) and the gold standard in both ears was assessed using *Kappa* statistics and the agreement between the two frequency ranges ("*Hi* test" and "*Lo* test*"*) was assessed using the Mcnemar test.

A descriptive analysis of the response detection time on the AABR with the *Hi-Lo CE-chirp*® stimulus was conducted for the cases with "Pass" results on the final test.

In this study, the TOAE results were described only for the newborns with altered results in the TB-ABR.

RESULTS

The casuistic is composed by 50 newborns, 22 (44%) males and 28 (56%) females, and seven had risk factors for hearing loss (hereditary factors, congenital infection, hyperbillirubinemia/ blood transfusion). Upon screening, the newborns had a mean of 34.34 (24-44.68) hours of life and mean gestational age of 37.5 weeks.

This casuistic did not have cases where the results (normal/abnormal) from the TB-ABR to 500Hz and 2 kHz stimuli were different. Either both frequencies had threshold level within established normal standards, or both had altered. In other words, there were no cases where the newborn had normal results for one of the frequencies and altered results for the other.

The results show that 96% of the newborns had normal results in both ears, 2% altered in both ears and 2% altered in only one ear. One case of bilateral hearing loss and one case of unilateral hearing loss were observed.

Among the altered cases, one newborn had a disorder suggestive of bilateral auditory neuropathy. The second case had a unilateral profound sensory neural hearing loss. Conductive or mixed hearing losses were not observed in the present study.

The percentage distribution of the results of the AABR with *Hi-Lo CE-chirp*® stimulus and TB-ABR for the right ear showed that of the 49 newborns with normal TB-ABR, 38 passed the AABR with *Hi-Lo CE-chirp*® stimulus while 11 newborns failed it. On the left ear, for the 48 newborns with normal gold standard, only 26 passed the AABR. There were no false negative cases observed for both ears.

This study describes the results (Pass/Refer) of the AABR with *Hi-Lo CE-chirp*® stimulus on the right and left ears. Twenty (40%) newborns had different results on both ears, with statistically significant differences between the ears (p=0.012).

The left ear has a greater number of "refer" results (48%) than the right ear (24%). The "Pass" and "Refer" results, on the left ear were similar (52% and 48%, respectively).

When comparing the AABR results to those of the gold standard, it was observed that 22% of the newborns had different results on the right ear and 44% on the left ear.

The right ear had 12 “refer” cases on the AABR, of which 11 were false positive and one true positive case. Concerning the left ear, 24 “refer” cases were observed, of which 22 were false positives and two true positives. A high rate of false positives was observed on the AABR with *Hi-lo CE-chirp®* stimulus, especially on the left ear.

Table 1 shows the values for sensitivity, specificity, Positive Predictive Value (PPV) and Negative Predictive Value (NPV), accuracy, Youden test and Kappa coefficient, obtained for the AABR with *Hi-Lo CE-chirp®* stimulus, based on the results from the gold standard test (TB-ABR). Low Kappa coefficient and PPV values stand out. The low values of these statistics are due to the small prevalence of newborns with altered results.

Table 1 – AABR test measures with Hi-Lo CE-chirp® stimulus in 35 dBnHL intensity (n=50)

Measure	RE	LE
Sensitivity	100.0	100.0
Specificity	77.6	54.2
PPV	8.3	8.3
NPV	100.0	100.0
Accuracy	78.0	56.0
Youden Index	77.6	54.2
Kappa	0.12	0.09

Key: PPV – Positive Predictive Value; NPV- Negative Predictive Value
RE – Right Ear; LE – Left Ear

The results for each limited band of the *Hi-Lo CE-chirp®* stimulus were analyzed separately, for thee *Hi* component (“*Hi* Test”) and for the *Lo* component (“*Lo* component”). The gold standard used for the “*Hi* Test” was the 2000Hz TB-ABR and for the “*Lo* Test” the 500Hz TB-ABR.

Table 2 shows the results (Pass/Refer) for the “Hi Test” on left and right ears. Eight (16%) newborns had different results among the ears. The number of “ Refer” results of the left ear was greater than of the right ear. The p-value found on Fisher’s exact test indicates Independence between the results of both ears.

Table 2 – Distribution of results (pass/refer) of the “Hi test” in right and left ears (n=50)

RE	LE		Total
	Pass	Refer	
Pass	41 82.0%	8 16.0%	49 98.0%
Refer	0 0.0%	1 2.0%	1 2.0%
Total	41 82.0%	9 18.0%	50 100.0%

Key: RE=Right Ear; LE=Left Ear
Fisher’s exact Test: p=0.180

The analysis of the "*Hi* Test" according to the gold standard (TB-ABR to 2000 Hz stimuli) showed total agreement of the obtained results for the right ear (Kappa= 1). On the left ear, there were different results in seven (14%) newborns (Kappa= 0.32). No false negatives were observed in any ear; however, the number of "Refer" results and false positives was greater for the left ear. The right ear had 100% sensitivity, specificity, PPV, NPV, and for the left ear, the obtained values were 100%, 85.4%, 22.2% and 100%. The accuracy and Youden index had results of 100% on the right ear and 86% and 85.4% on the left ear.

Table 3 shows the analysis of "*Lo* Test" results (Pass/Refer) for the right and left ears. Eighteen (36%) newborns had different results among the ears.

Table 3 – Distribution of results (pass/refer) of the "Lo test" in right and left ears (n=50)

RE	LE		Total
	Pass	Refer	
Pass	24 48.0%	14 28.0%	38 76.0%
Refer	4 8.0%	8 16.0%	12 24.0%
Total	28 56.0%	22 44.0%	50 100.0%

Key: RE= Right Ear; LE= Left Ear
Fisher's exact Test: p=0.070

The comparative analysis of the "*Lo* Test" result with its respective gold standard (TB-ABR to 500 Hz stimuli) showed that 11% of the newborns had different results on the right ear (Kappa= 0.12) and 40% on the left ear (Kappa = 0.10). A greater number of "refer" and false positives were observed on the left ear. The right ear had values for sensitivity, specificity, PPV, NPV of 100%, 77.6 %, 8.3 % and 100%, respectively. For the left ear, the obtained values were 100%, 85.4 %, 22.2 % and 100 %. The accuracy and Youden index for the right ear were 100% and for the left ear, 86% and 85.4%.

A joint analysis of the results (Pass/Refer) was conducted for each component of the *Hi-Lo CE-chirp*® stimulus, or, for the "*Hi* Test" and the *"Lo* Test*"*, on the right and left ears, respectively (Tables 4 and 5).

For the right ear, the number of "Pass" results was greater on the "*Hi* Test" when compared to the "*Lo* Test". There were no "refer" cases on the "*Hi* Test" and "Pass" on the "*Lo* Test". On the left ear, two cases where the "Pass" result on the "*Lo* Test" and "Refer" on the "*Hi* Test" were observed. The "Refer" rate was always greater on the "*Lo* Test" and for the left ear.

Table 4 – Distribution of results (pass/refer) for the "Hit test" and "Lo test" on the right ear (n=50)

"Hi Test"	"Lo Test"		Total
	Pass	Refer	
Pass	38 76.0%	11 22.0%	49 98.0%
Refer	0 0.0%	1 2.0%	1 2.0%
Total	38 76.0%	12 24.0%	50 100.0%

McNemar Test: p=0.001

Table 5 – Distribution of results (pass/refer) for the "Hit test" and "Lo test" on the left ear (n=50)

"Hi Test"	"Lo Test"		Total
	Pass	Refer	
Pass	26 52.0%	15 30.0%	41 82.0%
Refer	2 4.0%	7 14.0%	9 18.0%
Total	28 56.0%	22 44.0%	50 100.0%

McNemar Test: p=0.002

There was a statistically significant difference between the "refer" percentages on both tests, and the "refer" percentage on the "*Lo* Test" was greater than on the "*Hi* Test", on both ears.

Descriptive and comparative analysis of the response detection time of the AABR with *Hi-Lo CE-chirp*® stimulus in 35 dBnHL intensity

The response detection time for the newborn group that passed the AABR with *Hi-Lo CE-chirp*® stimulus was calculated and shown in table 6. The left ear had higher mean time for response detection when compared to the right ear; with similar standard deviations for both ears.

Time distributions may be seen, in approximation, on the box-plots in Figure 1.

Comparing the mean times on both ears though the t-paired test, there is a significant difference between the mean times of both ears (p=0.002), and the mean of the right ear is smaller than the left ear.

Table 6 – Descriptive statistic values for response detection time (seconds) for the AABR with the Hi-Lo CE-chirp® stimulus on the right and left ears

Ear	n	Mean	Standard Deviation	Minimum	Median	Maximum
Right	38	63.8	41.8	21	59.5	174
Left	26	77.9	41.6	15	69	161

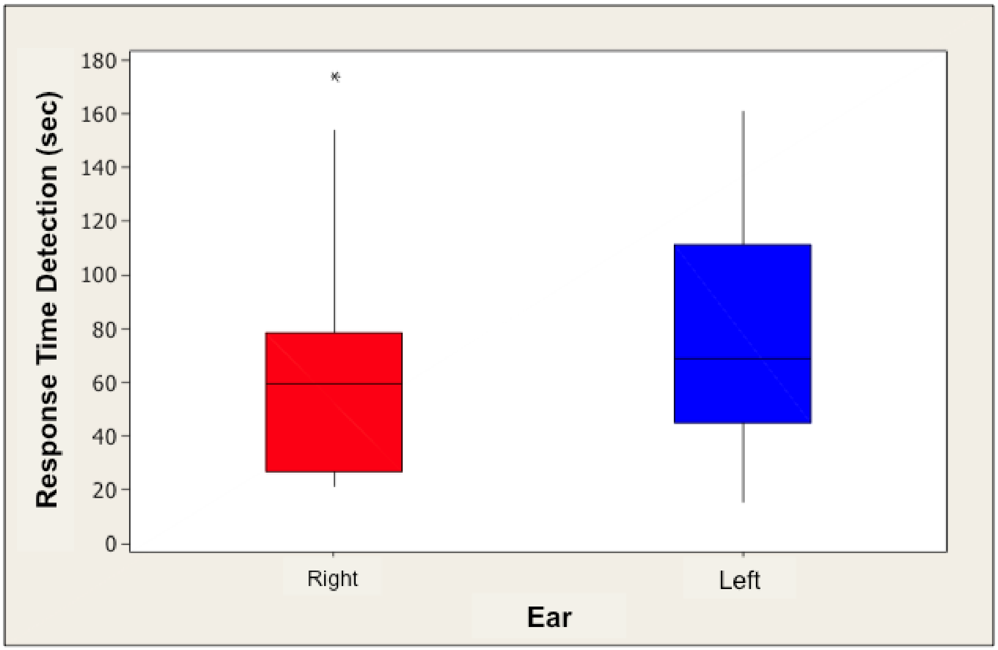

Figure 1 - *Box-plots* for response detection time for the AABR with the Hi-Lo CE-chirp® stimulus on the right and left ears

DISCUSSION

This study aimed to analyze the results from the AABR using stimulus with specific frequency ranges, presented simultaneously on the evaluated ear.

Of the 50 newborns who underwent the AABR, 12/50 (24%) "Failed" on the right ear and 24/50 (48%) on the left ear.

In this study, 28 newborns who "Passed" only one of the components, of which 11 on the right ear and 17 on the left ear. Thus, even though a "Pass" result was obtained in one of the components, the final AABR result was "Refer". Considering both right and left ears, 29% (29/100) had a "Refer" on the *Lo* component, while 10% (10/100) had a "Refer" on the *Hi* component. Therefore, the "Refer" results for the *Hi* and *Lo* components directly influenced the specificity analysis of the *Hi-Lo CE-chirp*® stimulus.

A study comparing a low frequency chirp (nominal frequency 100-480 Hz) to a 250 Hz tone observed that in the presence of masking, the wave V amplitudes decrease, showing an important participation of the high frequency components in obtaining an electrophysiological response[15]. According to researchers[14] in spite of the chirp improving neural synchronicity, the characteristics of frequency delay, needed to compensate cochlear delay limit the stimulus' frequency specificity. Furthermore, the greatest spectral dispersion observed in this stimulus, when compared to tone burst, may produce responses from undesirable frequency regions in the basilar membrane, and may thus limit its clinical usage.

In the present study, the number of "refer" results was always greater for the "Lo Test" when compared to the "*Hi* Test", so that it may not be believed that the band-limited high frequency, used in the studied stimulus could have "helped" the responses obtained with the band-limited lower frequency. In addition, the occurrence of two cases where the results were "Pass" for the *Lo* component ("*Lo* Test) and "Refer" for the *Hi* component ("*Hi* Test") on the left ear. It should be noted that these cases had normal results for the gold standard in 500 Hz and 2 kHz.

The number of false positives observed in this study for the *Hi-Lo CE-chirp*® stimulus was 22% (11/50 newborns) on the right ear and 44% (22/50 newborns) on the left ear. Considering both ears, 33% (33/100) of false positives were observed. No false negative cases were observed.

The results obtained for the *Lo* component that influenced the final AABR result may be due to the fact that the AABR is registered along with other electrical activities, and the sound should be identified among noise; therefore, a favorable signal-noise relationship becomes harder to achieve. A 2002 study with specific frequency chirps observed that the amplitude of wave V is smaller for lower frequencies[14]. Therefore, considering the results obtained for the *Lo* component of the *CE-chirp*® ("*Lo* Test"), detecting a response in weak intensity (35 dBnHL) may have been more difficult. Furthermore, low frequencies suffer greater influence of temporary conductive disorders such as the presence of vernix or secretion. In clinical audiology, middle ear disorders frequently account for greater hearing loss in the lower frequencies.

Another issue in this context is the fact that the frequencies chosen as gold standard had different spectral characteristics than the frequencies used in the automated procedure, especially regarding the *Lo* component. This fact may have influenced the normality results for the gold standard and consequently the determination of the specificity and sensitivity of the automated procedure. However, it should be noted that the frequencies used as gold standard have met the clinical registration possibilities of the Frequency Specific-ABR and the international protocol[16] that recommends that a minimum hearing test should include the frequencies of 500 Hz and 2000 Hz and that these have reliable calibration data.

On the other hand, other studies have been showing that the low frequency *CE-chirp*® have greater amplitudes than *tone burst*[15]. A national study[8] with newborns and small children has shown greater wave V amplitudes for the *narrow band CE-chirp*® in the frequencies of 0.5 and 2 kHz (0.148 uV and 0.166 uV, respectively) when compared to *tone burst*, especially in weak intensities 20-40 dB, which, in theory, would make this a promising stimulus to be used in NHS equipment.

An international study with adults showed that the low frequency chirp leads to a greater synchronicity of neural discharge, which is seen in the greater amplitude in relation to tone burst, especially in weak and moderate intensities[15]. However, the same authors state that differences, between the stimuli, in spectral magnitude may lead to differences in their neural excitement pattern and, consequently, to differences in the size of wave V amplitude[15].

Furthermore, it should be stressed that, in the present study, both limited bands of the *HiLo CE-chirp*® were presented at the same time, on the newborn's same ear. Researchers[13] believe that the simultaneous presentation of both band-limited stimuli may reduce the efficiency in response detection due to interference caused by the stimuli. In spite of the present study having used a cut-off frequency between frequency ranges, the result may still have been influenced by the interference caused by simultaneous presentation.

The high rate of "Refer" for the *Lo* component (*"Lo* Test) and, consequently for the *HiLo CE-chirp*® stimulus ("*HiLo* Test"), with normal gold standard, increases the rate of false positives and decreases specificity. Consequently, there is an increase in the number of referrals for diagnosis and, thus, of the costs of hearing screening programs. The greatest rate of "refer" on the left ear may have been due to the occurrence of disorders in sound conduction caused by the remainder of vernix in this ear since, in this study; newborns who passed the NHS with TOAE, as well as those who failed it were assessed. In this study, in order to ensure a direct comparison between the ears, variables such as difference in impedance between the ears, order to begin evaluation and the newborn's state of consciousness were controlled. However, variables such as residual noise and fluid in ears were not controlled and may have influenced the findings. Rodrigues (2012) has not observed statistically significant differences in the amplitude and latency of wave V for the ABR with click and *narrow band CE-chirp*® stimuli, showing that the stimulus does not behave differently in different ears, which could influence the response detection in automated procedures. Therefore, the differences between the ears found in this study are probably due to differences in middle ear conditions since the author, differently from this study, evaluated only newborns and children with present otoacoustic emissions.

Thus, there is a need for new studies that will control middle ear conditions, not only with otoacoustic emission records, but also conducting tympanometry, which would explain not only the elevated number of false positives of the HiLo CE-chirp® stimulus, especially of the *Lo* component, but also the differences between both ears found in this study. These complementary procedures would enable discussions of issues such as if a "Refer" on the *Lo* component is caused by a conduction disorder or really by the stimulus characteristic and form of stimulation.

The mean type for response detection of the "Pass" cases in the NHS was approximately 69.76 seconds (17-174 seconds), similar time as that in the study with steady-state potential[5] that observed a response detection time that varied between 76 and 109 seconds between the different types of studied frequency specific chirps. Better results were observed in a study with band-limited stimulus in automated hearing screening procedures[13].

CONCLUSION

- The *HiLo CE-chirp*® stimulus has high sensitivity and low response detection time. However, it had low specificity for this small sample, especially due to the results from the stimulus' *Lo* component.
- The findings show that there is still need for improvement of this stimulus for use in

automated hearing screening procedures, since the false positive rate is an important fact for program success and an indicator of service quality. Therefore, further studies should be conducted and stimulus or response detection method optimization may be necessary, as well as using a higher level of stimulus intensity.

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RESUMO

Objetivo: estudar os resultados obtidos no Potencial Evocado Auditivo de Tronco Encefálico Automático (PEATE-A) com um estímulo *chirp* de bandas limitadas. **Métodos:** o PEATE-A com o estímulo HiLo *CE-Chirp®*, na intensidade de 35 dB nNA, foi registrado em 50 recém-nascidos (RN) com e sem indicadores de risco para deficiência auditiva (IRDA) e comparado ao PEATE por Frequência Específica (PEATE-FE). Foram analisados os resultados "passa/falha" para o estímulo *HiLo CE-Chirp®* e para os componentes *Hi* e *Lo*, separadamente e determinadas medidas de validação. O tempo de detecção de resposta no PEATE-A também foi determinado. **Resultados:** o PEATE-A com o *HiLo CE-Chirp®* apresentou alta taxa de falha (36%) e de falso-positivos (33%). Diferenças significantes entre as porcentagens de "falha" entre os dois componentes foram observadas, sendo a porcentagem de falha no componente *Lo* maior que no *Hi*, nas duas orelhas. O tempo médio de detecção de resposta foi de 63,8 segundos para a orelha direita e 77,9 para a orelha esquerda, sendo observadas diferenças estatisticamente significantes entre as orelhas (p=0,002). **Conclusão:** o estímulo de banda limitada apresentou tempo médio de detecção de resposta consideravelmente pequeno e alta sensibilidade, no entanto, devido a alta taxa de falso-positivos, apresentou baixa especificidade, mostrando a importância de novos estudos direcionados, principalmente, para o aperfeiçoamento da técnica e do estímulo, buscando futura aplicação clínica no PEATE-A.

DESCRITORES: Testes Auditivos; Audição; Recém-Nascido; Perda Auditiva

REFERENCES

1. Sharma A, Kraus N, McGee T, Nicol T. Developmental changes in P1 & N1 auditory responses elicited by consonant-vowel syllables. Clin. Neurophysiol. 1997;104:540–5.

2. Hurley RM, Hurley A, Berlin CI. Development of low-frequency tone burst versus the click auditory brainstem response. J Am Acad Audiol. 2005;16:114-21;quiz 122.

3. Stapells DR. Frequency-specific evoked potential audiometry in infants. In R. C. Seewald (Ed.) A Sound Foundation Through Early Amplification. Basel: Phonak AG 2000a. p13-31.

4. Dau T, Wegner O, Mellert V, Kollmeier B. Auditory brainstem responses with optimized chirp signals compensating basilar-membrane dispersion. J Acoust Soc Am. 2000;107:1530-40.

5. Stürzebecher E, Cebulla M, Elberling C, Berger T. New efficient Stimuli for Evoking Frequency-Specific Auditory Steady-State Response. J Am Acad Audiol. 2006;17:448-61.

6. Cebulla M, Stürzebecher E, Elberling C. Objective detection of auditory steady-state responses-comparison of one-sample and q-sample tests. J Am Acad Audiol. 2006;17:93-103.

7. Elberling C, Don M, Cebulla M, Stürzebecher E. Auditory steady-state responses to chirp stimuli based on cochlear traveling wave delay. J Acoust Soc Am. 2007;122(5):2772-85.

8. Rodrigues GRI. Estímulos CE-chirp® e narrow band CE-chirp® na avaliação eletrofisiológica audição: resultados clínicos em neonatos, lactentes e crianças. [Tese]. São Paulo(SP): Pontifícia Universidade Católica de São Paulo; 2012.

9. Rodrigues GRI, Lewis DR. Comparação dos estímulos clique e CE-chirp® no Registro do Potencial Evocado Auditivo de Tronco Encefálico. Rev Soc Bras Fonoaudiol. 2012;17(4):412-6.

10. Van den Berger E, Deiman C, Van Straaten HL. MB11 BERAphone hearing screening compared to

ALGO portable in a Dutch NICU: a pilot study. Int J Pediatr Otorhinolaryngol. 2010;74(10):1189-92.

11. Cebulla M, Shehata-Dieler W. ABR-based newborn hearing screening with MB11 BERAphone1 using an optimized chirp for acoustical stimulation. Int J Pediatr Otorhinolaryngol. 2012;76:536-43.

12. Cebulla M, Elberiling C. Auditory Brain Stem Responses Evoked by Different Chirps Based on Different Delay Models. J Am Acad Audiol. 2010;21(7):452-60.

13. Cebulla M, Stürzebecher E, Elberling C, and Müller J. "New click-like stimuli for hearing testing," J Am Acad Audiol. 2007;18:725-38.

14. Bell SL, Allen R, Lutman ME. An Investigation of the use of band-limited chirp stimuli to obtain the auditory brainstem response. Int J Audiol. 2002;41(5):271-8.

15. Wegner O, Dau T. Frequency specificity of chirp-evoked auditory brainstem responses. J Acoust Soc Am. 2002;111:1318-29.

16. British Columbia early hearing program (BCEHP). Diagnostic audiology protocol [pdf document] 2008. [acessoem 12 jan 2011]. Disponívelem: http://www.phsa.ca/NR/rdonlyres/EADo&2EA-OCOE-40C6-83A-557357C14DA5/32441/DAAGPProtocols1.pdf.

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Mailing address:
Mabel Goncalves Almeida
Avenida Hugo Viola, 750 apt 503
Vitória – ES – Brasil
CEP: 29060-420
E-mail: mgafono@yahoo.com.br