RELATIONSHIP BETWEEN MIDDLE LATENCY AUDITORY EVOKED POTENTIALS AND THE AUDITORY PROCESSING DISORDER: CASES STUDY

Relação entre potenciais evocados auditivos de média latência e distúrbio de processamento auditivo: estudo de casos

Ana Carla Leite Romero (1), Bruna Balisa Sorci (2), Ana Cláudia Figueiredo Frizzo (3)

ABSTRACT

The Auditory Evoked Middle Latency Response is one of the most promising objective tests in audiology and in revealing brain dysfunction and neuro-audiologic findings. The main advantages of its clinical use are precision and objectivity in evaluating children. This study aimed to analyze the auditory evoked middle latency response in two patients with auditory processing disorder and relate objective and behavioral measures. This case study was conducted in 2 patients (P1 = 12 years, female, P2 = 17 years old, male), both with the absence of sensory abnormalities, neurological and neuropsychiatric disorders. Both were submitted to anamnesis, inspection of the external ear canal, hearing test and evaluation of Auditory Evoked Middle latency Response. There was a significant association between behavioral test and objectives results. In the interview, there were complaints about the difficulty in listening in a noisy environment, sound localization, inattention, and phonological changes in writing and speaking, as confirmed by evaluation of auditory processing and Auditory Evoked Middle Latency Response. Changes were observed in the right decoding process hearing in both cases on the behavioral assessment of auditory processing; auditory evoked potential test middle latency shows that the right contralateral via response was deficient, confirming the difficulties of the patients in the assignment of meaning in acoustic information in a competitive sound condition at right, in both cases. In these cases it was shown the association between the results, but there is a need for further studies with larger sample population to confirm the data.

KEYWORDS: Auditory Perception; Evoked Potentials, Auditory; Auditory Perceptual Disorders

INTRODUCTION

The Middle Latency Auditory Evoked Potential (MAEP) is one of the most promising objective tests for identifying central auditory nervous systems (CANS) alterations. It is made up of a series of waves that occur between 10 and 80 milliseconds (ms) after the initial auditory stimulus. Characterized by negative peak waves (N) and positive peak waves (P) it is represented by the following sequence of alphabetized letters: P0, Na, Pa, Na, Pb, Nb. The first registered wave is the Na with latency around 12 to 15 ms, followed by the Pa.
with 25 ms, and then the Nb and Pb. The deflection analysis of the Na is the most important, since its path is more constant.

The response analysis criteria are a function of the latency values (milliseconds-ms) and amplitude (microvolt-iv), being that the decrease in intensity provokes an increase in the latency values and a decrease in the amplitude values. The amplitude is the functional changes indicator, because the latency values have many variations.

The MAEP is an important tool in the evaluation of cerebral function. In recent years, research has shown that these potentials relate to the nuclei and the auditory pathways situated in the thalamo-cortical region and the primary auditory cortex, mainly in the thalamo-cortical tract. The recording of these potentials reflect the cortical activities involved in the primary listening skills (recognition, discrimination, and figure-ground) and non-primary listening skills (selective attention, auditory sequence and audio-visual integration).

The MAEPs can also be used to confirm or even study clinical conditions related to the Auditory Processing Disorder (APD), aiding in the neurodiagnosis and contributing to the understanding of the CANS. Its main clinical advantages are its accuracy and objectivity, since they are not dependent on patient response and can be very useful in the evaluation of children with auditory processing (AP) alterations and in the monitoring of the therapeutic process.

Any loss or setback that occurs during the stages of the AP cause what is called the APD. The goal in evaluating the AP is to determine the presence or absence of the disorder, describe the extent of either, evaluate the maturation of the CANS, detect the “location” of the hearing dysfunction, define the learning preference skills, establish the rehabilitation plan and assess the treatment benefits or refer the case to other professionals. The behavioral assessment of the central auditory function is made up of special tests that observe auditory behavior, such as dichotic tests, monaural low-redundancy tests, temporal processing tests, and binaural interaction tests.

In Brazil, the tests most frequently used are the dichotic digit tests, the staggered spondaic word tests (SSW), pediatric tests with contralateral and ipsilateral competitive messages (PSI-CCM and ICM) and synthetic sentence tests with contralateral and ipsilateral competitive messages (SSI-CCM and ICM). Temporal processing tests are skill recognition and temporal order of non-verbal stimuli, the tests most frequently used are the pattern sequence tests of frequency and duration. The monaural low-redundancy tests assess the auditory closure as in the low-pass filtered speech and speech-in-noise tests.

The types of problems involved in the CAPD are centered around the decodification, codification and organizational processes. The difficulty with decodification is caused by the inability to give meaning to auditory sensorial information, for example, the process relating to the analysis of the language’s phonemic system. The problem with codification relates to the inability to integrate auditory sensorial information and associate it with other sensorial or cognitive information. The difficulty with organization lies in the inability to organize acoustic events in time.

The goal of this study was to analyze the middle latent auditory evoked potentials in two patients with auditory processing disorder and list the objective and behavioral measures.

PRESENTATION OF CASES

The cases studies presented here are the descriptive analysis type.

The cases in the study were identified as follows: (1): Patient 1 (P1): J., 12 years old, 4th grade in elementary school, born at full term; (2): Patient 2 (P2): A., 17 years old, last year of high school, born at full term.

Both were subjected to basic audiology evaluations, central auditory processing exams and middle latency auditory evoked potential tests at the Phonoaudiology Department’s School Clinic of the institution closest to them. Both patients are seen at the Audiology Clinic of the institution closest to them.

First the patients were subjected to a medical history exam, a conductive hearing inspection and audiological evaluations using the Interacoustics audiometer model AD-28 and the Interacoustics AZ-7 middle ear analyzer, in addition to using the Bio-logic System Corporation’s portable system for recording evoked responses – the Traveler Express model – for measuring the middle latency evoked potential.

The simplified evaluation of the auditory process began with the cochleo-palpebral reflex test using the musical instrument, the agogô. Jingle bells were used in the sound localization test. For the non-verbal memory sequence test, the patients were asked to list the playing order of the following instruments: bell, jingle bells, coconut shells and agogô. After that test, the verbal memory sequence test was performed using the syllables PA, TA, CA and FA, during which the patients were asked to repeat the order the syllables were presented in. The battery of special tests began with the speech-in-noise...
research at 40dB SL. The low-pass filtered speech test was given at 50dB SL; the binaural fusion test was given at 40dB SL, with the test ear under low-pass condition and the contralateral ear under high-pass condition. The non-verbal dichotic test was given at 50dB SL above the average in the following order: free attention, attention directed to the right ear and attention directed to the left ear. The dichotic digits test assessed the binaural integration and the attention directed to the right and left ear. The SSW test (staggered spondaic word test) was performed at 50dB SL on the non-competitive right (NCR), competitive right (CR), non-competitive left (NCL) and competitive left (CL) ears. The PSI test was given in Portuguese (the monotic hearing test and the dichotic test with sentences) at 40dB SL with contralateral competitive messages (CCM) and ipsilateral competitive messages (ICM), this last one at –10, –15 dB HL.

Patients were set up in reclining chairs and asked to remain awake during the auditory evoked potential exam. The electrical impedance was below 5 kohms and the electrode difference was no more than 3 kohms. The electrodes were placed on the skin in such a way that the active electrodes would remain in the C3 and C4 positions in reference to the lobes of the right ear (A2) and the left ear (A1), resulting in the combination C4/A2 and C3/A1, ipsilateral recording (ai) and contralateral recording (ac), simultaneously, using the two equipment channels in accordance with the International Standard.

Tone burst stimuli were used in the monaural modality, applied at 70dB HL randomly at a speed of 10 stimuli/second, 100ms of analysis time, bandpass filter 3 to 100 Hz with alternating polarity, sensitivity of 75 µV.

In the analysis of this test, we compared the tracings of amplitude and latency of the Na and Pa waves. The amplitude was measured from the Na negative peak to the Pa positive peak. The latency measurement was established at the maximum deflection point of the Na and Pa wave. The ear effect was found when in the comparison of one ear to the other (RE and LE), the amplitude of one ear was significantly lower than the other (50%), which could be the ipsilateral or contralateral to the site of injury or dysfunction. The electrode effect was determined when in the comparison of the right hemisphere measurement (C4/A2) with the left (C3/A1) the amplitude of one hemisphere was significantly lower (50%) than the other hemisphere, which could be the ipsilateral or contralateral site of injury or dysfunction.

This study was approved by the Ethics Committee of the institution of origin according to the protocol n.º 183/07.

■ RESULTS

In the medical history exam, both cases showed written and spoken phonoarticulatory switching, had difficulty understanding conversation, had difficulty localizing sounds, were delayed in learning reading and writing and had a history of otitis in the first years of life. Currently, both patients appear to be in good general health, don’t use medication and have phonoaudiological therapy in the areas of oral motricity and oral and written language.

The tonal thresholds by air conduction were an average of 20dB HL for P1 and 05dB HL for P2 for the frequencies of 250 to 8000 Hz and the acoustic immittance measures showed type A timpanometry curves, bilaterally, in both cases with contralateral acoustic reflexes present at an average level of 100 dB for P1 and P2.

Table 1 corresponds to the results of the auditory proccessing research. Observed in patient 1, low-redundancy monotic tests (white noise and filtered speech) altered in the right ear. In patient 2, the staggered spondaic word test SSW was altered in the right ear. The responses obtained from the auditory processing test suggest alterations of the low grade decodification type in the right ear of patient 1, and the moderate grade decodification type in the right ear of patient 2.

The values presented in Table 2 correspond to the responses of the middle latency potential of the studied patients. The Pb component wasn’t identified because only the Na-Pa-Nb components were part of this study’s analysis criteria.
Table 1 – Auditory processing research results

<table>
<thead>
<tr>
<th>TESTS PERFORMED</th>
<th>RESULTS P1</th>
<th>RESULTS P2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cochlear-palpebral Reflex</td>
<td>Present</td>
<td>Present</td>
</tr>
<tr>
<td>Sound localization skills</td>
<td>5 hits in 5 directions – normal</td>
<td>5 hits in 5 directions – normal</td>
</tr>
<tr>
<td>Sequential memories for verbal sound</td>
<td>2 hits in 3 syllables – normal</td>
<td>3 hits in 3 syllables – normal</td>
</tr>
<tr>
<td>Sequential memories for non-verbal</td>
<td>3 hits in 4 instruments – normal</td>
<td>3 hits in 4 instruments – normal</td>
</tr>
<tr>
<td>Speech with white noise test</td>
<td>RE 56% LE 80% - right ear has alteration (decodification – low grade)</td>
<td>RE 72% LE 88% - normal</td>
</tr>
<tr>
<td>Filtered speech test</td>
<td>RE 64% LE 76% - right ear has alteration (decodification – low grade)</td>
<td>RE 88% LE 88% - normal</td>
</tr>
<tr>
<td>Non-verbal dichotic test</td>
<td>Free attention RE 10 LE 14 Guided hearing to the right - 23 hits – normal</td>
<td>Free attention RE 16 LE 16 Guided hearing to the right - 24 hits – normal</td>
</tr>
<tr>
<td>Dichotic digit test</td>
<td>Binaural Integration RE 96% and LE 96% - normal</td>
<td>Binaural Integration RE 100% and LE 97.5% - normal</td>
</tr>
<tr>
<td>SSW</td>
<td>Quantitative evaluation: condition CR – 97% CL – 92%</td>
<td>Quantitative evaluation: condition CR – 77.5% CL – 90% (decodification – moderate grade)</td>
</tr>
<tr>
<td>Quantitative evaluation: no effect</td>
<td></td>
<td></td>
</tr>
<tr>
<td>normal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PSI</td>
<td>Dichotic test – 100% in both ears Monotic test: RE – 100% for 0dB and</td>
<td>Dichotic test – 100% in both ears Monotic test: RE – 80% for 0dB and</td>
</tr>
<tr>
<td></td>
<td>-10dB and 90% for –15dB LE – 90% for 0dB, 100% for –10dB and 70% for</td>
<td>-15dB. LE – 80% for 0dB, 100% for –10dB and 70% for –15dB.</td>
</tr>
<tr>
<td></td>
<td>-15dB.</td>
<td></td>
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</tbody>
</table>

LEGEND: SSW = staggered spondaic word test; PSI = pediatric speech intelligibility test; RE= right ear; LE= left ear; CR = competitive right; CL = competitive left.

Table 2 – Latency and amplitude recordings for each ipsilateral and contralateral wave (Na, Pa, Nb and Pb) and the Na-Pa amplitude values

<table>
<thead>
<tr>
<th></th>
<th>LATENCY</th>
<th>AMPLITUDE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Na</td>
<td>Pa</td>
</tr>
<tr>
<td>RE P1</td>
<td>C4A2 ai</td>
<td>20.6 ms</td>
</tr>
<tr>
<td>RE P1</td>
<td>C3A1 ac</td>
<td>15.6 ms</td>
</tr>
<tr>
<td>LE P1</td>
<td>C3A1 ai</td>
<td>16.3 ms</td>
</tr>
<tr>
<td>LE P1</td>
<td>C4A2 ac</td>
<td>16.3 ms</td>
</tr>
<tr>
<td>RE P2</td>
<td>C4A2 ai</td>
<td>23.4 ms</td>
</tr>
<tr>
<td>RE P2</td>
<td>C3A1 ac</td>
<td>25.1 ms</td>
</tr>
<tr>
<td>LE P2</td>
<td>C3A1 ai</td>
<td>31.5 ms</td>
</tr>
<tr>
<td>LE P2</td>
<td>C4A2 ac</td>
<td>15.7 ms</td>
</tr>
</tbody>
</table>

LEGEND: RE= right ear; LE= left ear; P1 = patient1; P2 = patient2; C4/A2 = right hemisphere; C3/A1 = left hemisphere; ai = ipsilateral record; ac = contralateral record; ms= milliseconds; μV = microvolts;* = ear effect; **= electrode effect.
Auditory evoked potentials and the auditory processing disorder

The amplitude values Na-Pa in the contralateral RE C3/A1 suggest abnormalities for patient 1 (P1). In the comparison of the right and left ear measurements you find the ear effect (*). In addition, in the comparisons between the right hemisphere (C4/A2) and the left (C3/A1), the measurements of the left hemisphere are 50% less than those of the right hemisphere, which shows the electrode effect (**) also in patient 1 (P1).

In regards to patient 2 (P2), differences between the right and left ear, the ear effect (*), differences between the right (C4/A2) and left hemisphere (C3/A1), and the electrode effect (**) were also observed. In both cases the electrical activity observed in the contralateral RE C3/A1 was also less in relation to the other measures and more specifically, in patient 2 (P2) the absolute latency of the Pa wave was also elongated in all measures.

** DISCUSSION **

In this study, the combined use of the behavioral tests AP and MAEP was useful and helped to better investigate the function of the central auditory system of the two studied cases diagnosed with Auditory Processing Disorder (APD).

According to the literature, people with DPA have difficulty hearing and understanding in reverberant or noisy conversational environments. Also found are those who have difficulty identifying sound source and maintaining attention focus. The alterations can show up in varying ways, among them are: distraction – loss of ability to concentrate, difficulty understanding speech-in-noise and difficulty in the expression of speech and learning in reading and writing. These difficulties are more evident in patients with alterations in sound information decodification and were coincident with those identified during the medical history exam in the two cases studied.

The data in Table 1 show test alterations related to auditory closure skills, the speech-with-white-noise and the filtered speech test, showing alterations in the right ear for patient P1. For patient P2, the quantitative analysis of the SSW showed alterations in the right competitive hearing condition. These findings suggest difficulty in receiving sound information, especially when the test is performed with degraded acoustic information or under difficult hearing conditions in the right ear, for both cases. The conclusion of the exam indicates an auditory processing alteration of the low grade decodification type in P1 and moderate grade in P2.

The latency values found for Na, Pa and Nb didn’t have very large discrepancies for the normality value for patient P1 (table 2). The literature on the subject suggests an average age bracket of 20.65 ms for Na and 29.81 ms for Pa and of 20.7 ms for Na and of 35.3 ms for Pa. As for the patient P2 the latency values of Pa were elongated in comparison with the values obtained from the literature for the same average age bracket of 17.91 ms for Na and of 29.41 ms for Na and 20.77 ms for Na and of 31.07 ms for Pa compared to values 23 ms and 37 ms recorded in patient P2.

The latency of Pa should not surpass 35 ms in people without injuries or auditory dysfunctions. The neural origin of the Pa wave is attributed to the medial part of Herschel’s gyrus and the recognition and discrimination skills at the auditory cortex level, those skills which are damaged in patient P2.

The electrical activity observed in contralateral RE C3/A1 was always less and produced ear effect in both cases, suggesting acoustic reception damage of the right contralateral auditory pathway. The literature has reported that the ear effect is sensitive in detecting disorders of the auditory pathway and processing of sound information.

In the MEAP test, analysis of the responses recorded on the left hemisphere is much lower when compared to the other measures, as is shown by the electrode effect. This finding sets auditory cortical dysfunction and results in recognition, discrimination and figure-ground skills impairment, among others and association of auditory information with linguistics information.

Significant information which is related to the association of altered auditory skills in the AP behavioral exam with the MEAP test were observed in this study, which confirms the effectiveness of using behavioral and electrophysiological findings for the diagnosis and treatment of individuals with APD.

The behavioral assessment of the AP showed losses in the auditory decodification process, characterized by the damaged auditory closure skills and by the patient’s difficulty in the reception of sound information under difficult hearing conditions. The MEAP exam confirms this damage since its answer shows that the right contralateral pathway and the left hemisphere are deficient in both cases. The association between the results of the auditory processing tests and the MEAP were confirmed for at least two studied cases, suggesting the need for further studies with larger sample collections to confirm these findings.

** CONCLUSION **

The comparative analysis of the test results suggests the association of the alterations of the AP
behavioral exam and the alterations of the MEAP exam.

In the behavioral exam, both cases were found to have difficulties in the acoustic reception of information (right decodification damages). The MEAP test confirms these damages since the response of the right contralateral pathway and the left hemisphere are deficient and configure auditory cortical pathway dysfunctions.

The MEAP exam proved to be a useful tool in the diagnosis of auditory pathway disorders for the studied cases allowing for the objective evaluation and association with AP behavioral tests, which justifies its use in patients with APD.

RESUMO

O Potencial Evocado Auditivo de Média Latência é um teste objetivo promissor na audiologia na pesquisa neuro-diagnóstica das disfunções do sistema auditivo. Tem como vantagens a precisão e objetividade na avaliação e por isso é útil em crianças. O presente estudo teve como objetivo analisar os potenciais evocados auditivos de média latência em dois pacientes com distúrbio de processamento auditivo e relacionar as medidas objetivas e comportamentais. Para tanto foi realizado estudo de caso de dois pacientes (P1= feminino, 12 anos; P2= masculino, 17 anos), ambos com ausência de alterações sensoriais, distúrbios neurológicos, neuropsiquiátricos. Ambos foram submetidos à anamnese, inspeção do meato acústico externo, avaliação audiológica e avaliação do exame de potencial evocado auditivo de média latência. Houve associação significante entre os resultados dos exames comportamentais e objetivos. Na anamnese, houve queixas referentes à dificuldade de escuta em ambiente ruidoso, localização sonora, desatenção, além de trocas fonológicas na escrita e na fala. Foram observadas alterações no processo de decodificação auditiva à direita em ambos os casos na avaliação comportamental do processamento auditivo e no exame de potencial evocado auditivo de média latência a resposta da via contralateral direita foi deficitária, confirmando as dificuldades dos pacientes estudados na atribuição de significado às informações acústicas em condição de competição sonora à direita nos dois casos. Para os casos estudados comprovou-se a associação entre os resultados, porém há necessidade de novos estudos com maior amostra para confirmação dos dados.

DESCRIPTORES: Percepção Auditiva; Potenciais Evocados Auditivos; Transtornos da Percepção Auditiva

REFERENCES