# *Brainstem Auditory Evoked Potential in Individuals with Conductive and Sensorineural Hearing Losses*

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## RESUMO

**Introdução:** O potencial evocado auditivo de tronco encefálico (PEATE) além de determinar o nível mínimo de resposta eletrofisiológica auditiva, auxilia na caracterização do tipo de perda auditiva e na localização topográfica da lesão.

**Objetivo:** Descrever os achados no PEATE em indivíduos com perdas auditivas condutivas e neurossensoriais.

**Métodos:** Levantamento dos dados das medidas de imitância acústica, audiometria tonal e vocal e PEATE por meio de prontuários de 86 indivíduos, de três a 63 anos de idade, atendidos do Laboratório de Investigação Fonoaudiológica em Potenciais Evocados Auditivos do Curso de Fonoaudiologia da FMUSP nos anos de 2003 e 2004.

**Resultados:** Obtiveram-se 53 orelhas com perda auditiva condutiva, das quais 28% apresentaram resultados dentro da normalidade e 72% alterados ($p<0,001$). 109 orelhas apresentaram perda auditiva neurossensorial de grau leve a profundo, 40% com resultados dentro da normalidade e 60% alterados ($p=0,005$).

**Conclusão:** Frente à diversidade de achados encontrados, torna-se importante conhecer os tipos de traçados do PEATE esperados para cada tipo e grau de perda auditiva, garantindo desta forma diagnósticos mais precisos.

**Unitermos:** potenciais evocados auditivos, perda auditiva neurossensorial, perda auditiva condutiva.

## SUMMARY

**Introduction:** The brainstem auditory evoked potential (BAEP), besides determining the minimal sound level that elicits auditory electrophysiological response, helps the characterization of type of hearing loss and topographic localization of the lesion.

**Objective:** To describe BAEP findings in individuals with conductive and sensorineural hearing losses.

**Methods:** Data of acoustic immittance measures, tonal and vocal audiometry and BAEP results were gathered from the files of 86 subjects with ages ranging from 3 to 63 years, who had been through audiologic evaluation at the Speech-Language Pathology and Audiology Laboratory on Auditory Evoked Potentials of the Speech-Language Pathology and Audiology Course of the School of Medicine of University of São Paulo, during 2003 and 2004.

**Results:** 53 ears presented conductive hearing loss, of which 28% showed results within normal limits and 72% had impaired results ($p<0.001$; statistically significant difference). 109 ears presented mild to profound sensorineural hearing loss, 40% of which with results within normal limits and 60% with impaired results ($p=0.005$; statistically significant difference).

**Conclusion:** Considering the diversity of findings, it is important to know all different possibilities of BAEP configurations expected for each kind and degree of hearing loss, in order to guarantee more precise diagnosis.

**Key-words:** auditory evoked potentials, sensorineural hearing loss, conductive hearing loss.

## INTRODUCTION

Hearing is one of the most important means of communication between man and the world and, because of it, precocious detection of hearing alterations is extremely important.

Among all objective methods of hearing evaluation, brainstem auditory evoked potential (BAEP) is considered the most used precocious potential on clinical practice. This potential evaluates the integrity of hearing pathway from hearing nerve to brainstem and it occurs during the 8 first milliseconds (ms) from the beginning of acoustic stimulation. It is a type of method used on newborn evaluations and on individuals who there is a difficulty to evaluate through conventional audiological procedures (1).

BAEP is formed by seven waves. I, III and V are the most visible ones. In relation to the place of origin of these waves, the most accepted classification nowadays is: I – distal portion at brainstem of hearing nerve; II - proximal portion at brainstem of hearing nerve; III – cochlear nucleus; IV - superior olivar complex; V - lateral lemniscus; VI - inferior colliculus and VII - medial geniculate body (2).

The record of this potential is analyzed by morphology, latency and amplitude of waves, amplitude V-I relation, latency / amplitude relation, threshold of electrophysiological responses, interpeak breaks and binaural comparison (3).

The largest amplitude wave is V, which can be identified in intensities that are close to audiological threshold of an individual. Its latency also varies with intensity in a systematic way, i.e., when stimulus intensity is reduced, its latency increases (4).

According to the literature, BAEP is not used only to determine the minimum level of hearing responses, but also to distinguish the type of hearing loss, topographic localization of lesion on hearing nerve or on brainstem, monitoring of posterior fossa surgery and of patients in ICU (%). Any type of hearing alteration, such as conductive or sensorineural for instance, results in changes on record of this potential.

Otitis media is a type of disease that causes conductive hearing loss most of time, and it is very common in children (7). Nevertheless, in many cases, convencional audiologic tests are not done because such children do not cooperate with them, so it is necessary the use of objective tests, such as brainstem auditory evoked potential. According to the literature, the alterations occur on BAEP record in cases of conductive hearing loss, where can occur an increase of latencies value of waves I, III and V with normal interpeaks I-III, III-V and I-V (8).

Noise, chemical agents and genetic alterations are common causes of irreversible sensorineural hearing loss in both children and adults (9). Other risky factors which are also causes of hearing impairment are: premature condition, low weigh (under 1500g), hyperbilirubinemia that requires exsanguinotransfusion, congenital infection, cranio-facial anomalies, ototoxic medication, bacterial meningitis, and others (10). BAEP is one of the audiological exams used when diagnosing individuals exposed to this factors.

According to this study, sensorineural hearing losses in high frequencies of cochlear origin affect the morphology of BAEP waves and retro cochlear dysfunction (11). In hearing losses of light and moderate level in high frequencies, the BAEP record can be the same as the record obtained from ears with normal hearing, in relation to absolute latencies (12). In this way, it is necessary to study the effects of these alterations on records of this potential.

It is essential to know the features of BAEP in conductive and sensorineural hearing losses because of its importance on audiological diagnosis. Therefore, the target of this study was to describe the findings on brainstem auditory evoked potential in individuals with conductive and sensorineural hearing losses.

## MATERIAL AND METHODS

The current study was developed at *Laboratório de Investigação Fonoaudiológica em Potenciais Evocados Hearing s do Curso de Fonoaudiologia da Faculdade de Medicina da Universidade de São Paulo (*Speech-Language Pathology and Audiology Laboratory on Auditory Evoked Potentials of the Speech-Language Pathology and Audiology Course of the Medicine School of University of São Paulo). The audiological evaluation data were obtained through the study of the individual forms assited during 2003 and 2004.

86 individuals aging from 3 to 63 years of age took part on this study. In order to select samples, it was considered the following inclusion criteria: absence of neurological implication and presence of conductive and sensorineural hearing loss.

Audiologic evaluation, previously done, made part of the anamnesis, what could be seen from external acoustic meatus, using otoscopic HEINE, acoustic immittance measures obtained from GSI-33 – Grason-Standler; tonal and vocal audiometry using GSI 68 – Granson-Stadler; tonal and vocal audiometry using GSI 68 - Grason-Stadler and brainstem auditory evoked potential using a portable Traveler-Express from Biologic.

Conductive hearing loss diagnosis was done when the presence of air bone gap between bone and air pathways was higher or the same as 15 dB, air pathway was under normal limits and tympanometry curve type B, with absence of contralateral and ipsolateral acoustic reflexes. Yet, sensorineural hearing loss diagnosis was done when bone and air pathways thresholds were in low with absence of gap between them, in the presence of tympanometry curve type A, even if contralateral and ipsolateral acoustic reflexes were present or not.

The classification used to hearing loss degree was the one proposed by the researchers in 1970 (13), though using tonal threshold average through air pathways in the frequencies of 2000, 3000 e 4000 Hz, because it is the greates energy band from the click, what is a acoustic stimulus that expels brainstem auditory evoked potential.

Brainstem auditory evoked potential was done at 80 dB NA to clicks and classified as normal and altered, considering the grade and type of hearing loss. After that it was done the analysis in relation to types of alterations found on the records of potentials, based on values of absolute latency of waves I, III, V, and absence of them.

After collecting data, the results from each ear were analyzed and studied separately. The results of this study were submitted to statistical analysis, through Mann-Whitney Test*,* in which the value of 0.050 (5%) was defined as level of significance, and statistical significant values were marked with an asterisc. Together with this test, it was done a descriptive analysis of the obtained data, i.e. the types of alterations found on BAEP records we described, for both individuals with conductive and sensorineural hearing loss.

## RESULTS

From 172 evaluated ears, 53 (31%) presented conductive hearing loss, 109 (63%) presented sensorineural hearing loss and the others, 10 ears (6%), presented normal hearing threshold.

From 53 ears with conductive hearing loss, 15 (28%) presented normal results on BAEP and 38 (72%) were altered. The alteration found was an increase on absolute latencies of waves I, III and V, though with normal values of interpeak latencies I-III, III-V and I-V (Table 1).

It was observed the difference statistically significant between normal and altered results on BAEP to conductive hearing losses, where there was a larger percentage of altered results on this type of hearing loss (Table 1).

In relation to ears that presented sensorineural hearing loss, it was observed that hearing loss degree varied from light to profound. 44 ears (40%) had normal results on BAEP and 65 (60%) had them altered. It was checked from the increase on values of absolute latency of waves to total absence of them (Table 1).

On Table 2, it was done the comparison of number of ears that presented normal results and number of ears that presented them altered to sensorineural and conductive hearing losses.

It was not observed the differences statistically significant among the number of ears that presented normal results and among the number of ears that presented them altered, for both conductive and sensorinerual hearing losses (Table 2).

If we consider the grade of hearing loss, from the 32 ears with conductive hearing loss of light grade (60%), 12 of them (23%) presented normal records on BAEP and 20 (37%) presented them altered. From the 14 ears with moderate conductive hearing loss (26%), 2 of them (4%) presented normal records and 12 (23%) presented them altered. In relation to the 7 ears with moderate severe hearing loss (13%), 6 of them (11%) presented alteration on record of BAEP (Table 3). Conductive hearing losses of severe and profound grades were not found.

Through statistical analysis done, we can observe that to conductive hearing loss of light grade it did not occur difference statistically significant between normal and altered results on BAEP. On the other hand, to conductive hearing loss of moderate grade, it was observed difference statistically significant between normal and altered results, and a difference statistically significant on hearing loss of moderate severe grade, with a larger percentage of altered results on these two grades of hearing loss (Table 3).

From the 17 ears with light sensorineural hearing loss (16%), 15 of them (14%) presented normal records and two (2%) presented them altered. From 23 ears with moderate sensorineural hearing loss (21%), 15 (14%) presented normal records on BAEP and eight (7%) presented them altered. In relation to the 26 ears with moderate severe hearing loss (24%), 12 (11%) presented some type of alteration on the record of BAEP. On the 15 ears with severe sensorineural hearing loss (14%), all records were altered, what was observed on the 28 ears with profound hearing loss (25%), whose records were not visualized on waves I, III and V (Table 4).

The statistical analysis showed that, to sensorineural hearing losses of light, severe and profound grades, it occur differences statistically significant between normal and altered results on BAEP, with a higher percentage on altered results only on hearing losses of severe and profound grades. To light sensorineural hearing loss, it was observed higher percentage on normal results. On the other hand, to moderate and moderately severe sensorineural hearing losses, it was not observed differences statistically significant between normal and altered results, with a higher percentage on normal results on these two types of hearing loss grades (Table 4).

The observed alterations on light sensorineural hearing loss were: absence of wave I and presence of waves III and V with normal absolute latencies and presence of waves I, III and V with higher absolute latencies of waves I and III.

The alterations that follow were found on moderate sensorineural hearing loss: absence of wave I and presence of waves III and V with normal latencies (12.5%), absence of waves I and III and presence of wave V with normal latency (25%), presence of waves I and III with normal latency and presence of wave V with higher absolute latency (12.5%), absence of wave I and presence of wave III with normal absolute latency and wave V with higher absolute latency (12.5%), presence of wave I with normal latency and an increase on latencies of waves III and V (25%) and presence of waves I, III and V with absolute latencies of waves I and III increased (12.5%).

It was observed on moderate severe sensorineural hearing loss that in four ears (34%), there was presence of wave I with normal absolute latency, and waves III and V with increased latencies. In two ears (17%), wave I was absent and waves III and V were present, though, with absolute latencies increased.  Waves I and III were absent and wave V was present, with normal absolute latency in one of the ears (8%) that presented altered record. It was also observed, in relation to moderate severe sensorineural hearing loss that one ear (8%) presented wave I with increased latency and the other waves with normal latency, two ears (17%) presented absence of waves I and III and presence of wave V with increased absolute latency, one ear (8%) presented waves I, III and V with an increase of absolute latencies of waves I and III and normal interpeaks in one ear (8%), waves I, III and V were absent.

In relation to ears with severe sensorineural hearing loss, we can notice the following alterations: seven ears (44%) with absence of all waves; one ear (7%) with absence of waves I and III and presence of wave V, with normal absolute latency; one ear (7%) with absence of waves I and III and presence of wave V, with increased absolute latency; two ears (14%) with absence only of wave I and presence of the other waves with normal latencies; one ear (7%) with presence of all waves, though with increased absolute latencies; one ear (7%) with wave I present on normal latency time, and the remaining waves with increased waves; one ear (7%) with presence of waves I, III and V and an increase of absolute latency of wave I and one ear (7%) with presence of waves I, III and V and an increase on latency of waves I and III.

On the 28 ears (26%) with profound sensorineural hearing loss, waves I, III and V were not observed.

## DISCUSSION

In this study was observed that on conductive hearing losses the absolute latencies of waves I, III and V were predominantly increased and the interpeaks I-III, III-V and I-V were normal, and this was the only alteration found on record of BAEP. These findings agree with the literature, which reports alteration on record of BAEP in conductive hearing losses. It can occur increases on latency values of waves I, III and V with interpeaks I-III, III-V and I-V in normal condition (8).

On conductive hearing loss, not counting the loss grade (light, moderate and moderately severe) it occurred a higher number of altered results on BAEP, tough with difference statistically significant only to moderate and moderately severe hearing losses.

It is known that sensorial cells of Corti organ present two functional systems, one is called of “high intensity” composed by internal ciliated cells, connected to the largest part of afferent neural fibers, and another one called of “low intensity”, composed by external ciliated cells, which constitute the cochlear amplifier and interact with the former system, soothing it in order to respond to low intensity stimuli (14).

Therefore, the occurrence of such results on conductive hearing losses can be justified by the fact that the acoustic stimulus reaches cochlear area weakened, due to peripheral involvement, eliciting the responses of external ciliated cells which do synopsis with only 10% of the afferent neural fibers and need some time to soothe the internal ciliated cells, enlarging the latencies of waves of BAEP (14), although this is done in high intensity.

We cannot avoid talking about the number of altered records to individuals with conductive hearing loss, as there was an increase of hearing loss grade, to losses of light and moderate grades. To losses of moderately severe grade, the percentage of altered results was the same, when compared to records obtained on moderate grade losses.

In relation to sensorineural hearing losses of light and moderate grade, it was checked that large part of records of BAEP (88% in light hearing loss and 65% in moderate one) presented alterations. Such results agreed with the literature, which focuses on that ears with light to moderate hearing loss in high frequencies can work in the same way as in normal ears, in relation to absolute latencies of waves of BAEP (12).

On sensorineural hearing loss, opposed to conductive hearing loss, it occurred a larger number of normal results on BAEP to hearing losses of light, moderate and moderately severe grades, although difference statistically significant had been only verified to light hearing loss (p=0.001).

This can be explained by the fact the internal ciliated cells, which are responsible for conducting moderate / high intensity sounds, receive the largest part of afferent innervation of cochlea, doing synopsis with 90% of afferent neural fibers, and translating cochlea vibrations to stimulate hearing nerve terminals, stimulating it quickly delaying latencies of waves which compose BAEP (14,15).

In the cases of moderately severe sensorineural hearing loss, there were different findings on records of BAEP, from normal results, absence of wave I, presence of waves I and III to presence only of wave V, besides the increase on absolute latency of one or more waves simultaneously.

This diversity could be also noticed on severe sensorineural hearing loss, from presence of all waves with increased absolute latencies, absence of wave I, presence only of wave V with increased latency, to absence of all waves. The alterations observed probably occurred due to little neurons excitement, because of hearing sensitiveness reduction (16). This finding diversity on those records can occur because of different responses from hearing pathway in relation to little neuronal excitement.

In ears that presented profound hearing loss, it was observed the absence of waves on BAEP. Sensorineural hearing loss can prevent the effective stimulation on the involved areas of cochlea and, in that way, working as a filter to the stimulus (16). In this sense, profound hearing loss could endanger the acoustic stimulus conduction on afferent hearing pathway, preventing the stimulation of hearing nerve and, as a consequence, of the hearing pathway on brainstem.

For both hearing losses of severe and profound grades, it was observed the difference statistically significant when comparing the numbers of normal and altered results on BAEP ($p<0.001$), as all records obtained from both grades presented some type of alteration.

It is important to mention that there was an increase of altered record number to individuals with sensorineural loss, as there was an increase of hearing loss grade in light and severe grades. To profound loss, the percentage remained the same as the altered results, when comparing with records obtained from severe loss grade.

If we consider that in some cases it is impossible to have a basic audiologic evaluation which depends on individual responses, we have only the results obtained from an objective audiologic evaluation most of time, so, it is fundamental to know the record types of BAEP expected for each type of hearing loss grade, assuring a more precise audiologic diagnosis.

## CONCLUSION

Based on result analysis we may conclude that:

- In conductive hearing loss, no matter the grade, the most frequent finding on BAEP was the delay on absolute latencies of waves I, III, V and interpeaks I-III, III-V, I-V in normal condition.
- In sensorineural hearing loss, loss grade was a determining factor on BAEP; in hearing losses of light, moderate and moderately severe grades, the most frequent finding on BAEP was the presence of waves I, III, V with absolute latencies and interpeaks in normal condition; in hearing losses of severe and profound grades all records of BAEP were altered, with large diversity in relation to the type of alteration.
- Comparing hearing loss grade with records of BAEP, there was an increase on the number of altered records, according to the increase of hearing loss grade, for individuals with either conductive or sensorineural hearing loss.

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**Table1.** Comparison of number of normal and altered results on Brainstem Auditory Evoked Potential, for conductive and sensorineural hearing loss.

| | Hearing Loss conductive (N=53) | | Hearing Loss sensorineural (N=109) | |
|---|---|---|---|---|
| | N | % | N | % |
| Normal | 15 | 28 | 44 | 40 |
| Altered | 38 | 72 | 65 | 60 |
| Total | 53 | 100 | 109 | 100 |
| p-value | <0.001* | | 0.005* | |

**Table 2.** Comparison of number of normal results and number of altered results on Brainstem Auditory Evoked Potential, between conductive and sensorineural hearing loss.

| BAEP | Hearing Loss Conductive (N=53) | | Hearing Loss Sensorineural (N=109) | | p-value |
|---|---|---|---|---|---|
| | N | % | N | % | |
| Normal | 15 | 28 | 44 | 40 | 0.136 |
| Altered | 38 | 72 | 65 | 60 | 0.136 |
| Total | 53 | 100 | 109 | 100 | |

**Table 3.** Comparison of number of normal and altered results on Brainstem Auditory Evoked Potential according to conductive and hearing loss grade.

| Hearing Loss Grade | BAEP altered | | BAEP normal | | Significance (p) |
|---|---|---|---|---|---|
| | N | % | N | % | |
| Light | 20 | 37 | 12 | 23 | 0.092 |
| Moderate | 12 | 23 | 2 | 4 | 0.004* |
| Moderately Severe | 6 | 11 | 1 | 2 | 0.052 |

**Table 4.** Comparison of number of normal and altered results on Brainstem Auditory Evoked Potential according to sensorineural hearing loss grade.

| Hearing Loss Grade | BAEP altered | | BAEP normal | | Significance (p) |
|---|---|---|---|---|---|
| | N | % | N | % | |
| Light | 2 | 2 | 15 | 14 | 0.001* |
| Moderate | 8 | 7 | 15 | 14 | 0.124 |
| Moderately Severe | 12 | 11 | 14 | 13 | 0.677 |
| Severe | 15 | 14 | 0 | 0 | < 0.001* |
| Profound | 28 | 25 | 0 | 0 | < 0.001* |