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COMPARATIVE ANALYSIS OF THE PURE TONE AUDIOMETRY FINDINGS AND ABRS FOR PATIENTS WITH ACOUSTIC NEUROMAS

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Introduction

The first presumptive case of acoustic neurinoma dates back to the second half of the 18^{th} century. As Cushing noted, in 1777, Sandiford «documented a small body adherent to the right auditory nerve», which was found upon autopsy of a patient with deafness. Several reports on tumors possibly referred to the auditory nerve, but only in 1830 that Charles Bell gave an accurate description, characteristic of the British physician of the time, of what is a definitive case of acoustic neurinoma. A few years later, Cruveilhier published an outstanding and highly detailed report on the progression of clinical symptoms and the postmortem findings in a 26-year-old woman. Before the autopsy, he had considered the base of the skull as the likely tumor site. [1]

The symptoms of acoustic neuroma may develop at any age but usually occur between 30 and 60 years old. The unilateral acoustic neuromas are not considered hereditary. This disease affects males and females equally [2]. The progressive, high-frequency unilateral or asymmetric sensorineural hearing loss, the most common symptom of acoustic neuromas, is reported to occur in more than 95% of patients. It usually develops over months to years and is associated with impairment of speech disproportionate to the pure tone loss. In 10% cases, a sudden hearing loss occurs. It is attributable to the vascular interruption of the internal auditory artery. Based on the audiometry, speech discrimination scores, and speech reception thresholds, the normal hearing has been observed in 3 to 15% of acoustic neuroma cases. The mechanism for hearing loss is unclear, but it appears to be related to the compressive tumor effect on the vestibulocochlear nerve with the resulting injury of neuronal elements, vascular compromise, or both [3, 4].

Consequently, many patients experience little or no disequilibrium or imbalance. Once the tumor has grown sufficiently large to fill the internal auditory canal, it may continue to grow either by eroding or expanding the bone and/or by extending out into the cerebellopontine angle. The vestibular schwannomas, like other space-occupying lesions, show the symptoms referred to one of four distinct groups: cerebrospinal fluid space blockage, brainstem displacement, vessel compression or of nerve compression [5].

However, many patients with smaller acoustic neuromas have normal or near-normal hearing based on speech discrimination scores. There is no strict relationship between the tumor size and residual hearing quality. 5-15% of patients have sudden or fluctuating hearing loss associated with acoustic neuromas in. Such hearing loss, usually referred to as the “sudden deafness”, may improve spontaneously or in response to corticosteroid therapy [6]. Three to five percent of patients with acoustic neuromas have normal hearing at the time of diagnosis. The presence of unilateral tinnitus alone is a sufficient reason to evaluate an individual for acoustic neuromas. Vertigo and disequilibrium are uncommon presenting symptoms among patients with these tumors [7]. Rotational vertigo (the illusion of movement or falling) is more common when the tumors are small. On the other hand, the disequilibrium (a sense of unsteadiness or imbalance) is more common to larger tumors. Overall, approximately 40-50% of patients with acoustic neuromas complain about some balance impairment [8].

ABR is one of the most important non-invasive tests used for the diagnosis of retro-cochlear lesions. The waveform represents the specific anatomical points along the auditory neural pathway, i.e. the cochlear nerve and nuclei (waves I and II), superior olivary nucleus (wave III), lateral lemniscus (wave IV), and inferior colliculi (wave V). The absence of ABR waveforms is a useful screening index for retrocochlear pathologies. The intervals I-V, III-V and the latency of wave V are helpful indices. However, the sensorineural hearing loss is characterized by wave I falling outside the normal latency-intensity function. Wave V latency is normal at higher intensities, but as the intensity is decreased, it will be prolonged. The interwave latencies are either normal or shortened.

Materials and methods

The aim of this study was to compare and analyze the pure tone audiometry findings and ABRs for patients with acoustic neuromas.

This article was based on analyzing the clinical data of 97 patients with acoustic neuroma confirmed by MRI. Patients with acoustic neuromas were excluded from the study if ABR or MRI data were not available. They were treated and observed in the Clinic of Otolaryngology Warsaw National Medical University from 2010-2014. We subdivided the patients into 3 groups depending on the tumor stage, in this study was used the classification of Koos and Perneczky (Stage I – tumor located in the inner ear canal (IEC) and not beyond it. Stage II – tumor reaches the cerebellopontine angle, has a diameter in the axis IEC <2 sm. Stage III – tumor diameter in the axis of the IEC 2-3 cm, reaches the brain stem but not compresses it. Stage IV - tumor diameter in the axis IEC > 3 cm, reaches the brain stem and compresses it).The groups were as follows: group 1 (44 patients) – stage I; group 2 (35 patients) – stage II; group 3 (18 patients) – stage III. The latency of wave V and intervals I-V and III-V were evaluated. The Audio Evoked Potential Tester (EPTest, Pracownia Elekroniki Medycznej, Warsaw) was used to measure the latencies of different ABR components. The records were made using the rectangular electric clicks via an insert earphone (int. 90 dB; frequency rate 11.0/27.0/s; sweep, dur. 100.0 uj; t. 37.00 ms) with a digital low filter at 2000 Hz and a digital high filter at 200 Hz. The ABR was recorded using a one-channel system. The normal ABR values used in this study are showed in Table (Halla, 1997).

The upper limit of normal values for the selected ABR options (Halla, 1997)

Parameter	Values
Latency I	1.9 (ms)
Latency V	6.2 (ms)
Interval I-III	2.6 (ms)
Interval III-V	2.4 (ms)
Interval I-V	46 (ms)

Microsoft Office Excel 2013 was used for data management and statistical analysis. Continuous variables are presented in mean values ± standard deviation. Comparisons between groups were analyzed with Student's t-test for continuous variables and the Fisher's exact test for categorical variables. Statistical analysis was considered significant at $P < 0.05$.

Results

The first group comprises 44 patients with unilateral or prevalently unilateral sensorineural hearing loss. The mean pure tone threshold (500, 1000, 2000, 4000 Hz) at this group was 36.9 (±19.7) dB. As a result of ABRs, it was noticed that in 18 cases (40.91%) the waves were not detected. Wave V was recorded in 24 cases (54.55%). Only in 12 (27.27%) cases, all ABR waves were detected, indicating the sensitivity to the retrocochlear pathology. Among these cases, the average latency of wave V was 5.81 (±0.65) ms, interval III-V was 1.86 (±0.38) ms, and interval I-V was 4.65 (±0.66) ms. The second group consisted of 35 patients. The mean pure tone threshold (500, 1000, 2000, 4000 Hz) was 41.6 (±18.3) dB. In 60.00 % of the cases (10 patients), the waves were not detected. In 14 cases (40%), wave V was visualized, and in 22.86 % (5 cases) all ABR waves were detected, the mean latency of wave V was 5.83 (±0.53) ms, interval I-V – 4.33 (±0.6) ms, interval III-V – 2.16 (±0.62) ms. The third group was the smallest one and consisted of 18 patients. The mean pure tone threshold (500, 1000, 2000, 4000 Hz) was 51.1 (±15.5) dB. In seven cases (38.89%), wave V was noticed, in 55.56 % of cases (10 patients) the waves were not detected, in five cases (27.78%) all ABR waves were detected, indicating the retrocochlear pathology. The latency of wave V was 5.56 (±0.71) ms, interval III-V – 2.29 (±0.72) ms and interval I-V – 4.08 (±0.68) ms.

A relationship between tumor stage and waveform changes was apparent. Comparing the data of ABR records for the first, second and third tumor stage, a significant difference in interval III-V was observed. Comparison of intervals I-V and III-V among patients of different groups is presented in Figure 1.

After analysis and comparison of the pure tone average according to audiometry (500, 1000, 2000, 4000 Hz) and value of intervals I-V, III-V and latency wave V, it was noted that an increase in hearing loss increases the value of the intervals and value of latency wave V.

Discussion

The etymological mechanisms of sudden hearing loss and acoustic neuromas have not been completely explained yet. Berenholz (1992) explained that the sensorineural hearing loss occurs in acoustic neuromas due to tumor compression of the vestibule-cochlear nerve. The vestibule-cochlear nerve has a transition zone in myelination known as Obersteiner-Redlich zone. This is a region with variable length in which the myelin sheath of Schwann cells meets with oligodendrocytes. The transition zone of the vascular component is also located there. The peripheral vascular supply occurs longitudinally, whereas the glial segment does not have a regular standard, with few anastomoses. Therefore, there is a high potential for lesions in transition regions due to low vascularization and myelination. The compression of this area could lead to reversible neuropathy through blockage of nervous stimulus to the vestibule-cochlear nerve.

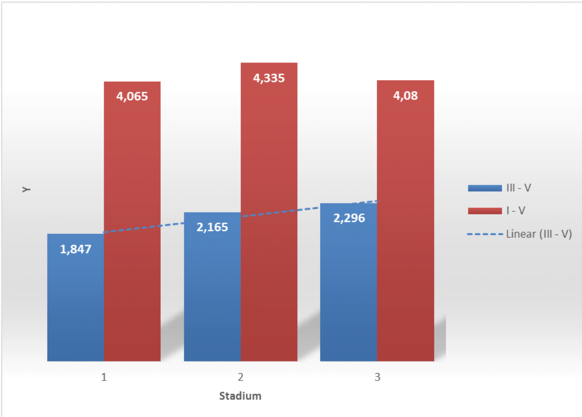

Figure 1. Comparison of intervals I-V and III-V among patients of different groups

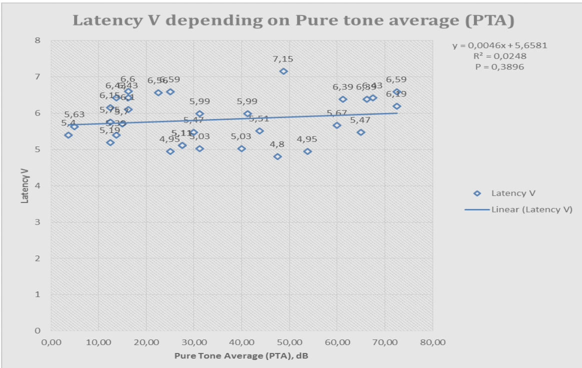

Figure 2. Latency of wave V depending on the hearing loss

The changes in the ABR records involve the total desynchronization (lack of the wave V) or other abnormalities of morphology (increase the interval III-V, I-V or latency V) in cases when the wave V is present. In our study the percentage of total desynchronization depends of the tumor size and represent in I stage – 40, 91%, in II stage – 60%, and in III stage- 55, 56%. This type of changes in morphology don't give us opportunity to observe the development and evolution of the tumor. The interpretation of this results can be only qualitative.

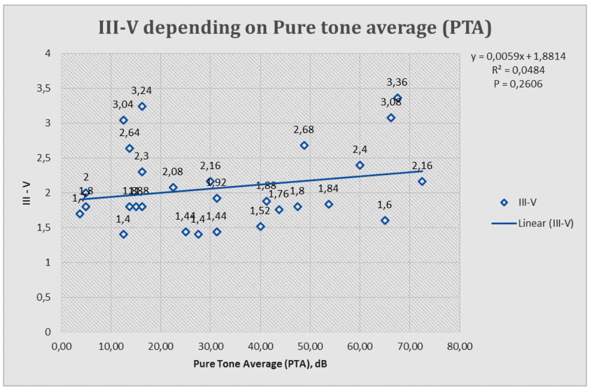

Figure 3. Value of interval III-V depending on the hearing loss

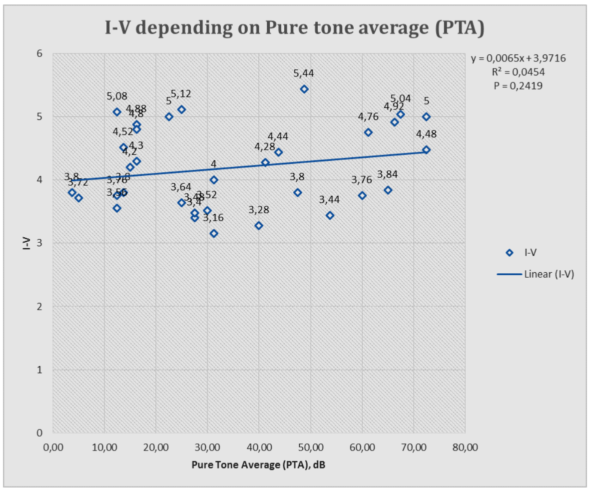

Figure 4. Value of interval I-V depending on the hearing loss

The percentage of abnormal morphology (increase the latency V, interval III-V and I-V) depends from the tumor size too. And represent in I stage – 59.09%, in II stage – 40 % and in III stage – 44, 45%. According to this data we may say that the biggest percent of changes in morphology is observed in cases when tumor was located in the inner ear canal and not beyond it (I stage).With the growth of the tumor (assumption - bigger stages) the presence of abnormal morphology of ABR records could decrease. That's why we may suggest that the observation of traces data in ABR increase for acoustic neuroma of small size. It could be useful for the investigation of the tumor growth/evolution and for choosing the treatment strategy, especially when MRI don't show any changes.

In acoustic neuroma the intervals I-V and III-V is frequently elongated. The ABR provides information with regard to auditory function and hearing sensitivity. However, it is not a true test of hearing and not a substitute for a formal hearing evaluation.

The general interpretation of the delay between wave I and wave III or V is that the pressure made by the tumor slows down the conduction of auditory impulses along the auditory nerve. The tumor probably mainly affects the transmission of the fibers around the outside of the nerve. These fibers come from the first turn of the cochlea and are specifically responsive to high-frequency sounds. The tumor may prevent the conduction in these fibers or may desynchronize their firing patterns. Since its generators are either absent or desynchronized, wave V from the basal turn is no longer recordable. One is therefore left with a delayed wave V initiated by fibers from the middle and apical turns of the cochlea. Wave I is generated by the auditory nerve fibers in the spiral ganglion and often remains normal. The surface of the recorded wave I is mainly generated by fibers from the basal turn of the cochlea near the stapes. Derived responses in patients with acoustic neuromas suggest that this selective impairment of the high-frequency fibers is the major cause for the prolonged I-V interval in the click evoked ABR (Eggermont & Don, 1986).

The size of the tumor has already been related to sensorineural hearing loss, with higher frequency of sensorineural hearing loss occurring in smaller tumors. Nevertheless, if only the size was fundamental to sensorineural hearing loss pathogenic factors, all large tumors should have sensorineural hearing loss symptom even in smaller sizes. The location of the tumor is more important than size (intracranial or extracranial location).

Conclusions

1. The majority of patients with acoustic neuroma has abnormal morphology of the ABR records or total lack of traces. The percentages of the total lack of morphology has tendency to increase with bigger stage of the tumor.

2. About 50% of ABR records in total group tumors present different traces abnormality. There was a trend towards an increase in the interval I-V, III-V and latency V with an increase of the tumor stage. The results may

indicate different mechanisms of development and growth of tumors which impact on extension of latency of waves. Confirmation and detailed explanation of these relationships can be established in prospective studies.

3. The threshold evaluated from ABR traces correlate with mean pure tone audiometry results. With the hearing loss aggravation the value of ABR parameters increases (interval I-V, III-V and latency wave V).

References

1. Stone JL: Sir Charles Balance. Pioneer British neurological surgeon. Neurosurgery. 1999;44:610-32.
2. Jamróz B, Niemczyk K. Acoustic neuromas – diagnostic and treatment methods. Otorynolaryngologia. 2013;12(1):8-18.
3. Agrawal Y, Clark JH, Limb ChJ, Niparko JK, Francis HW. Predictors of vestibular schwannoma growth and clinical implications. Otology and Neurotology. 2010:807-12.
4. Chaimoff M, Nageris BI, Sulkes J, et al: Sudden hearing loss as a presenting symptom of acoustic neuroma. Am J Otolaryngol. 1999;20:157-60.
5. Chung WY, Liu KD, Shiau CY, et al: Gamma knife surgery for vestibular schwannoma: 10-year experience of 195 cases. J Neurosurg. 2005;102 Suppl:87-96.
6. Bozorg GA, Kalamarides M, Ferrary E, et al: Conservative management versus surgery for small vestibular schwannomas. Acta Otolaryngol. 2005;125:1063-68.
7. Hasegawa T, Kida Y, Kobayashi T, et al: Long-term outcomes in patients with vestibular schwannomas treated using gamma knife surgery: 10-year follow up. J Neurosurg. 2005;102:10-6.
8. Kanzaki J, Tos M, Sanna M, et al: New and modified reporting systems from the consensus meeting on systems for reporting results in vestibular schwannoma. Otol Neurotol. 2003;24:642-48.
9. Myrseth E, Moller P, Pedersen PH, et al: Vestibular schwannomas: clinical results and quality of life after microsurgery or gamma knife radiosurgery. Neurosurgery. 2005;56:927-35.

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СРАВНИТЕЛЬНЫЙ АНАЛИЗ РЕЗУЛЬТАТОВ ТОНАЛЬНОЙ ПОРОГОВОЙ АУДИОМЕТРИИ И КСВП У ПАЦИЕНТОВ С АКУСТИЧЕСКОЙ НЕВРИНОМОЙ

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А н н о т а ц и я

Вступление. Акустические невриномы составляют около 6 % всех внутричерепных опухолей, около 30 % опухолей ствола головного мозга, а также 85 % опухолей в области мостомозжечкового угла.

Целью исследования был сравнительный анализ результатов тональной пороговой аудиометрии и КСВП у пациентов с акустической невриномой.

Материалы и методы. Нами были проанализированы клинические данные 97 пациентов с диагнозом акустической невриномы. Все пациенты проходили обследование и наблюдались на кафедре и в Оториноларингологическом отделении клиники Варшавского медицинского университета с 2010 по 2014 гг. Пациенты были разделены на 3 группы в зависимости от стадии опухоли. Анализировались результаты тональной пороговой аудиометрии и КСВП.

Результаты и дискуссии. В 1-ю группу входило 44 пациента. Средний порог слышимости (500, 1000, 2000, 4000 Гц) – 36,9±19,7 дБ. КСВП исследование показало, что в 18 случаях (40,91%) волны не были обнаружены. Волна V была зафиксирована в 24 случаях (54,55%). Только в 12 (27,27%) случаев волны КСВП были зафиксированы. Во 2-ю группу вошло 35 пациентов. Средний порог слышимости составил 41,6±18,3 дБ. При анализе КСВП в 60,00% случаев (10 пациентов) не было обнаружено волн. В 14 случаях (40%), волна V отмечалась, а в 22,86% (5 случаев) волны КСВП были обнаружены. Третья группа состояла из 18 пациентов. Средний порог слышимости – 51,1±15,5 дБ. В 7 случаях (38,89%) волна V была обнаружена, в 55,56% случаев (10 пациентов) волны не отмечались, в 5 случаях (27,78%) все волны были зафиксированы и указывали на ретрокохлеарную патологию.

Выводы. 1. Большинство пациентов с акустической невриномы имеет аномальную морфологию записей КСВП или полное ее отсутствие. Процент полного отсутствия морфологии имеет тенденцию к возрастанию с увеличением стадии опухоли. 2. Приблизительно в 50% записей КСВП в общей группе пациентов с акустической невриномой наблюдаются различного рода отклонения от нормы. Отмечена тенденция к увеличению интервала I-V, III-V и латентности V волны с увеличением стадии опухоли. Полученные результаты могут указывать на различные механизмы развития и роста опухолей. Подтверждение и подробное описание этих механизмов возможно в проспективных исследованиях. 3. В результате сравнительного анализа тональной пороговой аудиометрии и КСВП была обнаружена прямая корреляция. С увеличением потери слуха значение параметров КСВП увеличивается (интервал I-V, III-V и латентность V волны).

Ключевые слова: акустическая невринома, КСВП, сенсоневральная тугоухость.

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A b s t r a c t

Actuality. Acoustic neuromas comprise about 6% of all intracranial tumors, about 30% of brainstem tumors, and about 85% of tumors in the region of the cerebellopontine angle.

The aim of this study was to compare and analyze the pure tone audiometry findings and ABRs for patients with acoustic neuromas.

Materials and Methods. This article was based on analyzing the clinical data of 97 patients with acoustic neuroma confirmed by MRI. The comparison and analysis of the mean pure tone audiometry and ABR data established a direct correlation.

Results and Discussion. The first group comprises 44 patients with unilateral or prevalently unilateral sensorineural hearing loss. The mean pure tone threshold at this group was 36.9±19.7 dB. As a result of ABR, it was noticed that in 18 cases (40.91%) the waves were not detected. Wave V was recorded in 24 cases (54.55%). Only in 12 (27.27%) cases, all ABR waves were detected and demonstrated sensitivity to the retrocochlear pathology. The second group consisted of 35 patients. The mean pure tone threshold was 41.6 (±18.3) dB. In 60.00 % of the cases (10 patients), the waves were not detected. The third group was the smallest one and consisted of 18 patients. The mean pure tone threshold was 51.1±15.5 dB. In seven cases (38.89%), wave V was noticed, in 55.56 % of cases (10 patients) the waves were not detected, in five cases (27.78%) all ABR waves were detected, indicating the retrocochlear pathology.

Conclusions: 1. The majority of patients with acoustic neuroma has abnormal morphology of the ABR records or total lack of traces. The percentages of the total lack of morphology has tendency to increase with bigger stage of the tumor. 2. About 50% of ABR records in total group tumors present different traces abnormality. There was a trend towards an increase in the interval I-V, III-V and latency V with an increase of the tumor stage. The results may indicate different mechanisms of development and growth of tumors which impact on extension of latency of waves. Confirmation and detailed explanation of these relationships can be established in prospective studies. 3. The threshold evaluated from ABR traces correlate with mean pure tone audiometry results. With the hearing loss aggravation the value of ABR parameters increases (interval I-V, III-V and latency wave V).

Keywords: Sensorineural hearing loss, acoustic neuroma, auditory brainstem response (ABR)