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THE COMPUTER PROCEDURES TO ANALYSE THE PARAMETERS OF THE AUDITORY BRAINSTEM RESPONSES IN ADVANCED RETROCOCHLEAR TUMORS OF THE AUDITORY PATHWAY

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This investigation was aimed at a computer- supported analysis of the Auditory Brainstem Responses (ABR) recorded in both ears of 8 patients with unilateral tumor of the retrocochlear extracanalicular auditory pathway. Applying the computer procedure designed for processing the averaged ABR waveforms, the latencies in the time domain of waves I, III, V were calculated and the ratio of the amplitudes of those waves in both ears of the same patient was evaluated and correlated with the surgically verified size of the tumor.

1. Introduction

The tumors of the VIII, cochleo-vestibular (stato-acoustical), cranial nerve in its intracanalicular part and of the pono-cerebellar angle (extracanalicular) do not infiltrate the environmental structures and do not make methastases. Nevertheless, while growing-up they affect not only the hearing and the sense of equilibrium but the facial nerve function as well and, in the later stage, they may compress the breathing and cardiac centers in the brainstem creating an immediate life threat.The most important diagnostic tool in these cases of tumors are now advanced radiological techniques. Since they are expensive and not completely harmless, some audiological tests should be made as soon as possible before sending the patient to the radiologist. Among the appropriate audiological tests, the registration of the Auditory Brainstem Responses (ABR) can provide the most valuable data. The ABR waveforms are registered as variations of the electrical potential of the electrodes placed on the head of the subject after application of an acoustic stimulus into the ear [1]. Positive and negative surface electrodes are placed on both mastoids and a ground one on the forehead. To supress the influence of the environmental noises, the stimulus is repeated ca. 1000 times and the registered waveforms are averaged. The stimulus usually used is a 100 µs click delivered *via* the headphone with a repetition rate of 31 per second at the sound level choosen in the range from 0 to 100 dB HL and with alternating polarity that prevents some artefacts to occure [2]. The time analysis of the recorded ABR applies to the first 10 ms after the stimulus onset [1]. In this period, the auditory nerve and the primary auditory brainstem centers are activated. The normal ABR waveform includes five-seven maxima (waves) among which the first, third and fifth are the dominant ones. It is generally accepted that the source of the first wave is the distal part of the cochlear nerve, the third wave is generated mostly in cochlear nuclei and the fifth one in the lateral lemniscus nuclei [3].

The presented data concern the ABR registered for patients operated in the ENT Clinic of the Institute of Stomatology of the Warsaw Medical Academy. It seems that the proposed computer analysis can to some extent facilitate additionally in the evaluation of the ABR recordings in these cases.

2. Material and method

The material comprises a series of 8 cases, 5 women and 3 men aged from 38 to 50, with unilateral eight-nerve neuroma. Five of the cases were rightsided and 3 leftsided, all expanded already into the cerebello-pontine angle but not compressing yet the brainstem centers. They were operated upon in our Clinic in the years 1996–97. The recordings were made from the affected side while those from the opposite side served for inter-ear comparing purposes. The ABR from the two normal hearing young subjects (No 1 and No 2 in Table 1) served as referrences and 20 other normal ABRs were analysed to test the software used. The ABR were recorded on the ABR Acquisition System EPTEST, made in Poland [4]. Each record included 1000 integer numbers, representing the current ABR potential sampled every 10 µs; in this way the ABR run within the first 10 ms after the stimulus onset were stored.

The authors have designed the software to visualize the ABR waveforms and to determine the diagnostic parameters listed in the Introduction. The time plots of the recored waveforms were completed by the lines reffering to generally accepted time limits for normal latencies measured in healthy ears in response to the stimulation by the 90 dB nHL click (see Figs. 1, 2 and 3). The latencies accepted as normal are as follows [4]:

- the latency of the I wave – 1.6 ± 0.4 ms,
- the latency of the III wave – 3.8 ± 0.4 ms,
- the latency of the V wave – 5.6 ± 0.4 ms,
- the inter-ear latency difference – ± 0.2 ms.

In spite of the latency data, the authors did not found any generally accepted values concerning the inter-ear differences of the wave amplitudes. The lack of such values is certainly due to the great intersubject shape variability of the ABR waves. A step to

Table 1. The results of the evaluation of the ABR waveform parameters referring to the investigated subjects.

Subject No.	Size of the recognized pathology (mm)	Latency of wave I (miliseconds)	Latency of wave III (miliseconds)	Latency of wave V (miliseconds)	Amplitude of the ABR waves ratio: reference/pathological ear		
		! denotes the value beyond the limit			I wave	III wave	V wave
1	0	1.59 1.66	3.74 3.79	5.64 5.55	2.75	1.05	1.35
2	0	1.42 1.46	3.49 3.50	5.37 5.48	1.17	1.13	2.0
3	11	1.44 1.99	3.64 4.86!	5.44 6.07!	0.24	2.40	0.91
4	13	– 2.28!	3.67 3.68	– 5.54	–	4.57	–
5	15	1.42 1.48	3.61 4.29!	5.37 5.12	0.76	1.42	1.25
6	15	1.69 –	3.88 –	5.75 6.05!	–	–	1.50
7	25	1.59 1.42	3.89 –	5.18 –	2	–	–
8	30	1.14 1.70	3.55 –	– 6.94!	0.21	–	–
9	34	1.53 1.38	3.88 –	5.87 5.85	1.40	12.0	1.09
10	40	1.48 –	3.75 4.50!	– 5.42	6	16.5	–

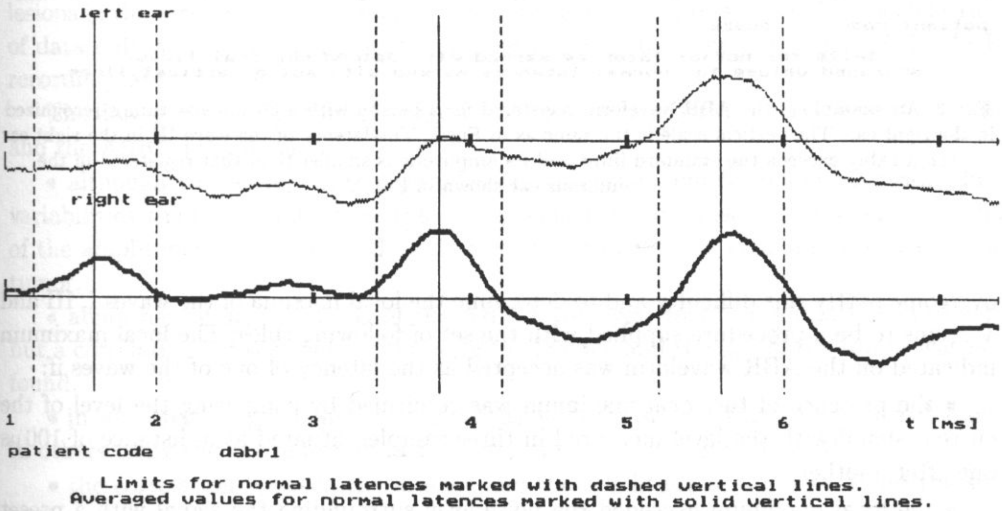

Fig. 1. An example of the ABR waveform registered in a healthy pair of ears. The vertical scale is approx. 10 μV/cm. The latences of the waves I, III and V do not exceed the standard limits. There are slight inter-ear differences in latences and amplitudes of the three waves.

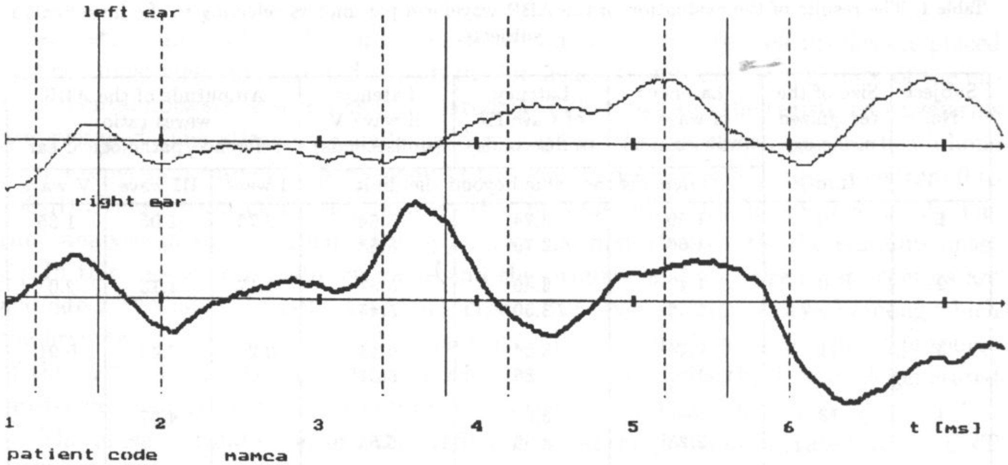

Fig. 2. An example of the ABR waveform registered for a person with a 15 mm size tumor recognized in the left ear. The vertical scale is the same as in Fig. 1. The latence of the wave III in the left ear remarkably exceeds the standard limit and its amplitude is smaller than that in the healthy ear.

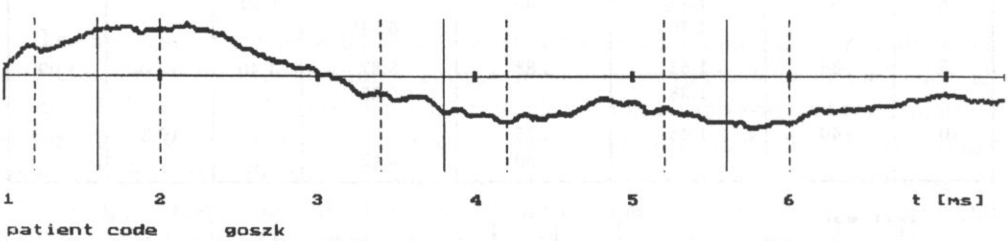

Fig. 3. An example of the ABR waveform registered for a person with a 30 mm size tumor recognized in the right ear. The vertical scale is the same as in Fig. 1. The latence of the wave III in the right ear remarkably exceeds the standard limit and its amplitude is smaller than that registered in the tumorous ear shown in Fig. 2.

overcome partly this difficulty and to determine the local maxima of the waves I, III and V seems to be a procedure supplied with the set of following rules: The local maximum indicated on the ABR waveform was accepted as the latency of one of the waves if:

- the presence of the local maximum was confirmed by comparing the level of the current signal with the level measured in three samples situated at a distance of 100 μs one after another,
- the local maximum exceeded the noise level surrounding the signal with a preset value of 1 μV,
- the individual time limits were taken into account to recognize a certain wave mode.

3. Discussion of the results

Table 1 shows the results of the evaluation of the ABR: the latencies of three waves and the ratio of the amplitudes of those waves registered in the healthy ear and in that with recognized pathology. The ABR parameters of the subjects starting from the No 3 up to No 10 are referred to the size of the tumor. The two first subjects, labelled No 1 and No 2, are of healthy, normal hearing persons.

An example of the ABR waveform recorded in a healthy ear is shown in Fig. 1. The wave latencies are within the above mentioned time limits, the amplitudes of all three maxima are distinct and high and there are no significant inter-ear differences.

An example of the ABR waveform from a patient with a relatively smaller (in this series) size of the tumor – 15 mm beyond the internal acoustic porus – is shown in Fig. 2. In this case the neuroma is recognized in the left ear however the right one is normal. The latencies of the waves III and V are beyond the normal time limits in the pathological ear but there are only slight differences in the wave amplitudes between a pathological and a normal ear.

An example of the ABR waveform registered for a patient with great size of the right ear tumor – 30 mm beyond the internal acoustic porus – is shown in Fig. 3. The amplitudes of the waves III and V are poor when compared with those recorded from the opposite ear. The latency of the wave I largely exceeds the normal limits. The inter-ear differences are substantial.

4. Conclusions

Because of the relatively small number of cases and the advanced size of tumoral lesions in the cerebello-pontine region, the material may be presented only as a collection of data only and some results of the proposed approach to the evaluation of the ABR recordings are preliminary.

The data presented in Table 1 suggest some correletion between the size of the tumor and the ABR's parameters:

- although the ABR wave amplitudes are subject to much greater interindividual variabilities than their latencies; there is a remarkable correlection between the ratio of the amplitudes of the wave III, registered in both subjects' ears, and the size of the tumor,
- abnormal latency patterns of the ABR waves were found in all pathological ears but a correlation between the extention of the latency and the size of the tumor was not found,
- in some pathological ears the identification of the wave III and V was feasible but in others using the above formulated criteria, no maxima could be found,
- the correlation between the latency and the amplitude of the wave I and the size of the tumor is poorer than in the case of waves III and V,
- for patients with wave III detectable in the ABR, there was a reversed correlation between the size of the tumor and the amplitude of wave III.

To summarize: Using the computer procedures described in the article to analyse the ABR waveforms in subjects with advanced unilateral retrocochlear tumors verified surgically, the following parameters seem to be most valuable:

- the presence/absence of the waves I, III and V,
- the normal/extended latencies of those waves,
- the inter-ear ratio of amplitudes of the wave III.

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