A METHOD OF AMPLITUDE-FREQUENCY ANALYSIS OF RHEOENCEPHALOGRAM

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In recent years, the method of rheoencephalography has found wide application in clinical research [1-3,6,7,9]. The author has used this method to investigate patients with tumors and vascular diseases of the brain. To analyze the rheoencephalogram, methods described in the literature were used [1,6,9,10]. Attention was paid to the shape of the curve, the number and conspicuousness of the accessory waves, and the regularity of the rheoencephalogram. The ratio between the duration of the ascending part of the rheoencephalogram (A) and the duration of all the waves (A + B, where B is the duration of the descending part of the rheoencephalogram) was determined.

Although this method of analysis of the rheoencephalogram revealed adequate information concerning the degree of filling and the state of tone of the blood vessels of the brain, sometimes this information is not adequate for revealing very small changes. For this reason, more recently a method of automatic amplitude-frequency analysis has been used for interpreting rheoencephalograms [4].

The wave of the rheoencephalogram is a complex wave which can be analyzed into groups of waves bearing definite relationship of time and space to each other. The rheoencephalogram obtained by means of the type RG1-01 rheograph was subjected to simultaneous and integral analysis automatically by means of a frequency-amplitude analyzer (a Japanese model EA-101). In the process of simultaneous analysis, the simple waves obtained by analysis of the rheoencephalogram were divided into seven groups with different frequency characteristics (see figure). Parallel with the simultaneous analysis, an integral analysis was carried out, the theoretical basis of which was the comparison of waves of different frequencies in accordance with their energy. The energy of a wave is proportional to the square of its amplitude. Integral analysis was carried out over periods of 10 sec. The amplitudes of the waves of each frequency were integrated for this time and a special pen made seven marks on a strip of paper, their height proportional to the total energy of the groups of waves off the corresponding frequency. If the energy content of a frequency component, expressed in per cent, is the object of the study, the squares of each amplitude are calculated and the energy content of waves of a particular frequency is determined in per cent by the formula:

$$\frac{(A_x)^2}{(A_1)^2 + (A_x)^2 + \ldots (A_n)^2} \cdot 100\%,$$

where $(A_n)^2$ is the square of the amplitude of the marker of integral analysis.

The rheoencephalograms of a healthy person and of a patient with cerebrovascular atherosclerosis are shown in the figure. Parallel recordings were made of the results of simultaneous and integral analysis.

The results of integral analysis were treated by application of the formula given above and are shown in the table.

Comparison of the two groups of data in the table shows a fall in the energy of the waves with frequencies of 2-4 and 4-8 cps on the rheoencephalogram of the patient with atherosclerosis. This change in the energy relationships of the waves may be attributed to an increase in the modulus of elasticity of the vessel walls, in agreement with data in the literature [5,8].

Measurements of the velocity of spread of the pulse wave (C) along the carotid arteries, made in the same patients, gave the following results: for the healthy person C = 500 cm/sec. This directly confirmed results of integral analysis, for the modulus of elasticity of the vessel wall and the velocity of spread of the pulse wave bear a direct relationship to each other:

$$E = \frac{C^2}{310 \cdot R},$$

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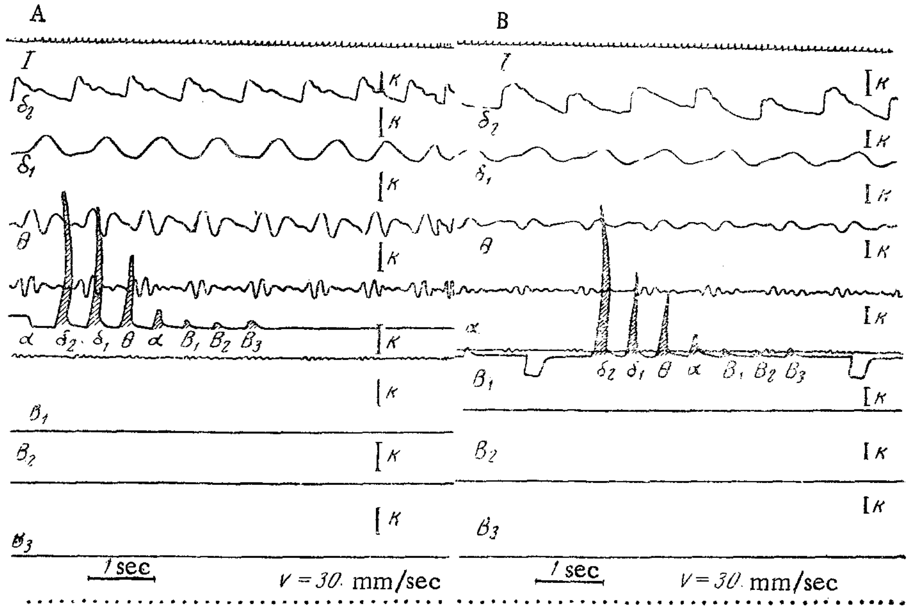

Rheoencephalogram of a healthy person (A) and of a patient with cerebrovascular atherosclerosis (B) with synchronized recording of their simultaneous and integral analysis: I – rheoencephalograms; δ_2, δ_1, θ, α, β_1, β_2, β_3 – groups of waves composing the rheoencephalogram, of frequencies 1-1, 2-4, 4-8, 8-13, 13-20, 20-30, and 30-60 cps, respectively; δ_2, δ_1, θ, α, β_1, β_2, β_3 – markers of integral analysis of the same frequencies arranged in the same order. The energy of the groups of waves of frequencies 13-20, 20-30, and 30-60 cps was low at the amplifications used, and in the bands of instantaneous analysis the waves of these frequencies cannot be seen.

Distribution of Energy of a Complex Wave of the Rheoencephalogram by Groups of Waves in a Healthy Person and a Patient with Cerebrovascular Atherosclerosis

Frequency (in cps)	Energy of groups of waves (in %)	
	Healthy	Patient
1—2	50.0	68.3
2—4	35.6	20.0
4—8	13.9	9.8
8—13	0.87	1.4
13—20	0.19	0.18
20—30	0.047	0.05
30—60	0.13	0.21

where E is the modulus of elasticity, C the velocity of spread of the pulse wave, and R a coefficient showing the ratio between the thickness of the blood vessel wall and the external radius of the vessel; 310 is a coefficient.

Analysis of the rheoencephalograms by the method of integral analysis revealed their minor details in cases when other methods did not permit this to be done. In addition, automatic amplitude-frequency analysis considerably facilitates the study of the rheoencephalogram when recorded for a long time. Comparison of the results of amplitude-frequency analysis with data given by other methods of assessment showed that with the former a much more complete picture may be obtained of the special features of the rheoencephalographic curve.

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