# ESTIMATION OF THE TONE OF THE BLOOD VESSELS OF THE BRAIN BY RHEOENCEPHALOGRAPHY

V. P. Zhmurkin, L. G. Okhnyanskaya, V. G. Osipova, and T. A. Masich

UDC 616.133.33-008.834-073.731

To determine the tone of the blood vessels of the human brain, two clinical methods are mainly used, orbital plethysmography as described by B. E. Votchal, and rheoencephalography. Whereas the first of these is based on the general principles of mechanical plethysmography, developed over a long period of time, the principles governing the interpretation of rheographic curves have only just been elucidated and have much in common with the principles of interpretation of the ordinary plethysmograms. A. M. Vein and M. A. Ronkin [1] have summarized the methods of analysis of the rheoencephalogram (REG) most commonly used in the Soviet Union and elsewhere, and to determine the tone of the blood vessels of the brain they recommend using the following indices (Fig. 1): h – the amplitude of the REG, indicating the degree to which the vessels are filled with blood; $\alpha$ – the time in seconds during which the curve rises to the apex, characterizing the ability of the vessels to stretch under the influence of the inflow of blood; $\beta$ – the time in seconds during which the curve falls, characterizing, according to these workers, the degree of elasticity of the vessels. Hence, the ratio $\alpha/\beta$ is an index of vascular tone, while the ratio $\alpha/(\alpha + \beta)$ is an index of the tonic state of the vascular wall; t – the time of spread of the pulse wave, measured from the Q wave of the ECG to the beginning of the rheographic wave. The number and size of the accessory waves (d) are also taken into account, for these are regarded as analogous to the polycrotic waves. The decrease in the number and size of the accessory waves and in the value of t and an increase in $\alpha/(\alpha + \beta)$ are usually regarded as signs of an increase in the tone of the blood vessels of the brain. Since Jenkner [4] concluded that the formation of the REG is almost entirely dependent on the movement of blood in the internal, and not in the external carotid artery, rheoencephalography has been increasingly extended to the functional diagnosis of cerebrovascular disorders.

However, the special features of impedence plethysmography, like the role of the extracerebral circulation, has received too little attention during analysis of the REG. The importance of those elements of the REG used to assess the tone of the blood vessels of the brain must be determined more exactly.

It has been shown [2,3] that the amplitude of the waves of the electroplethysmogram depends not only on changes in the volume of the vessels, but also of changes in the velocity of the blood flow within them. This means that, unlike with the ordinary plethysmogram, an increase in the amplitude of the REG may take place when the vascular tone is unchanged, or even increased if for some reason the systolic blood flow in them is accelerated (for example, during an increase in the blood flow in the trunk of the internal carotid artery).

To determine whether the indices h, $\alpha$, and $\beta$, and the shape of the REG curve and of its accessory waves may be used to assess the tone of the blood vessels of the brain, a comparison was made of the waves of the orbital plethysmogram (OP), corresponding to the filling of the branches of the internal carotid artery (the ophthalmic artery) with blood, the temporary plethysmogram (TP), reflecting the filling of the branches of the carotid artery, and the REG.

Since the formation of the REG depends mainly on changes in the level of filling of the blood vessels, it may be expected that with electrodes in the fronto-mastoid position the REG wave will be close in shape to the theoretical wave obtained by summation of simultaneously recorded OP and TP waves, reflecting the state of the circulation in approximately the same region (judging by the position of the pick-ups). The results of these investigations confirmed this suggestion.

It is clear from Fig. 2a and b that the actual REG wave was almost identical in its general fall, and also in the form and time coordinates of the peak and the accessory waves with the theoretical wave, whereas the ordinates of their apices did not coincide with the ordinates of the apices of either the OP or the TP wave.

No. 2 Department of Therapy, Central Postgraduate Medical Institute, and Laboratory of Clinical Physiology, Institute of Work Hygiene and Occupational Diseases, Academy of Medical Sciences of the USSR, Moscow (Presented by Active Member of the Academy of Medical Sciences of the USSR V. V. Parin). Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 62, No. 9, pp. 117-120, September, 1966. Original article submitted December 8, 1964.

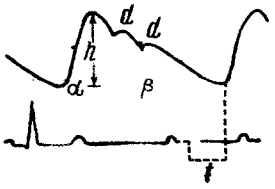


Fig. 1. Rheoencephalographic curve (top) and ECG (bottom). Explanation in text.

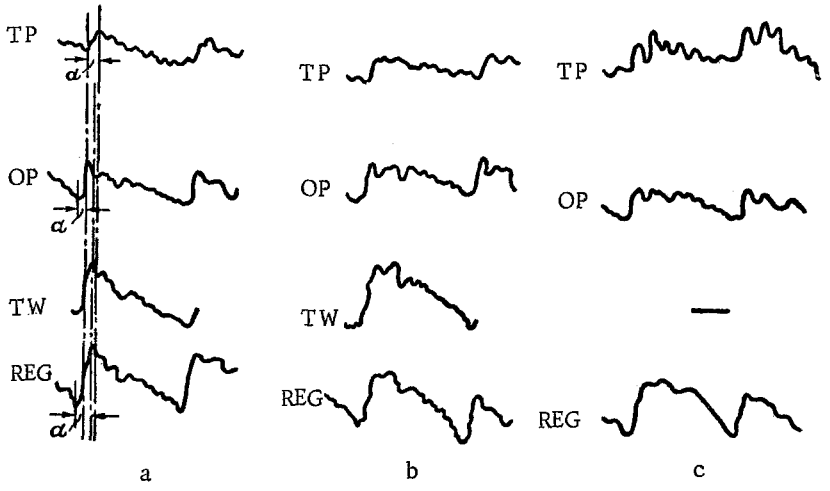


Fig. 2. Recording of the rheoencephalogram with electrodes in the fronto-mastoid (a and b) and fronto-occipital (c) positions: TP) temporal; OP) orbital plethysmogram; TW) theoretical wave; REG) rheoencephalogram.

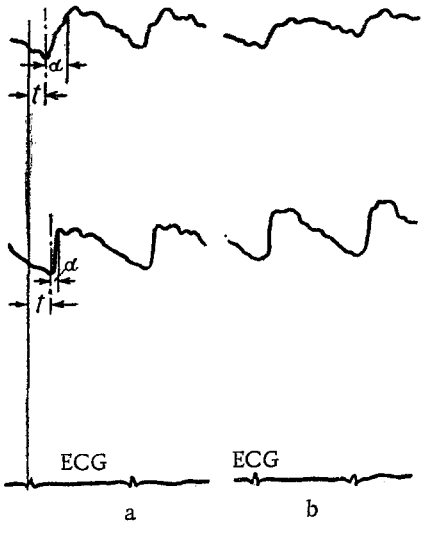


Fig. 3. Unilateral REG. a) top — with electrodes in the fronto-mastoid, bottom — in the temporo-temporal position (both electrodes on the same temple); b) top — with electrodes in the orbito-temporal, bottom — in the temporo-temporal position.

The coincidence of the ordinates of the main elements of the actual REG wave with the ordinates of the theoretical wave demonstrates that the area under the actual REG wave is the integral of the changes in the electrical resistance in the intracranial and extracranial systems of the circulation. Hence, both the amplitude of the REG wave and the ordinates of the apex and of the accessory waves are aggregated values which, in the general case, cannot be equal to only one of the added values. For this reason, the time intervals $\alpha$ and $\beta$, depending on the coordinates of the apex of the wave, cannot be used as criteria for determining the tone of the blood vessels of the brain, and consequently, nor can the ratios $\alpha/\beta$ and $\alpha/(\alpha + \beta)$.

For the same reason the number and size of the accessory waves of the REG also cannot be used as criteria. As Fig. 2c shows, the dicrotic waves on both the OP and the TP are sufficiently clearly defined, but on the REG wave recorded at the same time, the accessory waves can hardly be made out. This is understandable because when the characteristics of vascular tone in the systems of the internal and external carotid arteries are different, the changes in blood-filling (and in electrical resistance) in time in these cases also will differ, and consequently the coordinates and the size of the accessory waves must also be different. During summation, like the apices on the REG wave, the accessory waves of extracerebral and intracerebral origin may be added together, or they may occur in succession and cancel each other out (which probably took place in the case shown in Fig. 2c).

Hence, the criteria used to evaluate the tone from the data of the ordinary plethysmogram cannot be used unreservedly for the interpretation of the REG.

All the elements of the REG, including the time intervals $\alpha$, $\beta$, and $\underline{t}$, may change considerably in the same subject when the electrodes are placed differently. This is demonstrated by Fig. 3a (in which the dependence of $\alpha$ and $\underline{t}$ on the position of the electrodes is obvious) and Fig. 3b (marked differences are seen in the form of the REG when the orbital electrode is shifted to the temporal region).

Determination of the absolute values of the time of spread of the pulse wave ($\underline{t}$) from the interval between the Q wave of the ECG and the beginning of the REG wave is unacceptable not only because the coordinates of the apex of the wave are the results of summation, but also because the range of variation of the intervals from the Q wave of the ECG to the beginning of mechanical systole is 0.05 sec even in normal conditions (or QR of the ECG 0.02 sec and for the interval between R of the ECG and I of the BCG – 0.03 sec), which is commensurate with the time of spread of the pulse wave from the arch of the aorta to the blood vessels of the brain.

It may be concluded from the facts described above that the use of rheoencephalography for determining the tone of the blood vessels of the brain in accordance with the time parameters of the REG curve and its shape is not justified.

## LITERATURE CITED


1. A. M. Vein and M. A. Ronkin, Zh. Nevropat. i Psikhiat., 2, 282 (1962).
2. A. A. Kedrov and A. I. Naumenko, Problems in the Physiology of the Intracranial Circulation and Their Clinical Investigation [in Russian], Leningrad (1954).
3. A. A. Kedrov, A. I. Naumenko, and Z. Ya. Degtyareva, Byul. éksp. biol., 9, 10 (1954).
4. F. Jenkner, Confin. neurol. (Basel), 19, 1 (1959).


---