METHODS OF RHEOGRAPHY

(UDC 612.13.014.421.7:537.3+616.12-073.731)

G. I. Éninya and A. D. Valtneris

Department of Nerve Diseases (Head, Professor A. S. Pentsik)
and Department of Normal Physiology (Head, Docent A. P. Pavule), Riga Medical Institute
(Presented by Active Member AMN SSSR, V. V. Parin)
Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 60, No. 12,
pp. 108-110, December, 1965
Original article submitted June 6, 1964

The literature inadequately elucidates the problem as to how the shape and amplitude of a recording are affected by the direction of balancing, size of electrodes and distance between them, and by their longitudinal and transverse arrangement and methods of fixation.

In connection with this we undertook to elicit a number of practically important problems arising when using the method of rheography. We used rheographs designed by G. I. Éninya and P. A. Ondzuls. First we compared the operation of two different types of rheographs, one utilizing radio tubes and the other semiconductors. The basic problem was to evaluate the stability of their operation. The instruments were checked in an experiment on dogs and with recording of the rheograms of patients. We recorded the rheograms of the carotid artery (sutured into a skin flap on the neck) of a dog.

The circuit of the radio-tube rheograph was described earlier [2].

For the semiconductor rheograph, we used a 30,000 cycle electrical current. Its circuit is shown in Fig. 1.

The rheograms of the dog's carotid artery were recorded by both systems. Since it is impossible to record two rheograms simultaneously from the same place on one artery, we simultaneously recorded the rheogram and sphygmogram. To record the sphygmogram, we used the mechano-optical system designed by A. D. Valtneris [1] which makes it possible to record the pulse on an MPO-2 oscillograph by means of a pneumatic drive. Thus, we alternately recorded from the same place the sphygmograms and rheograms on the radio-tube and semiconductor rheographs. All recordings were displayed on the MPO-2 oscillograph. For simultaneous recording of the rheo- and sphygmograms, we placed on the carotid artery the sensing capsule of the mechano-optical system in which were attached two electrodes for recording the longitudinal and transverse rheograms. By means of contour analysis and mathematical calculations, it was established that the shape of the sphygmogram coincides with the rheogram recorded both by the radio-tube and the semiconductor apparatus. However, the tracings in the upper part of the anacrotic wave and in the incisura were poorly evidenced on the rheograms in comparison with the sphygmogram, but the additional waves on the catacrotic limb were more numerous and better evidenced. These differences were identical on the rheogram recorded by the radio-tube and semiconductor rheographs. This confirms that both rheographs give a recording similar in quality.

The rheographs we used are characterized by a high operational stability, which permits recording a rheogram without breath holding either by a person (Fig. 2A) or in the experimental animals (Fig. 2B). The respiratory movements in this case do not disturb the recording; therefore,the described rheographs can be used in the clinic and in experiments.

It was also our purpose to elicit the significance of the direction of balancing on the amplitude and shape of the rheogram. With reverse balancing, just as in ordinary balancing, the shape of the rheogram is not changed. Only the amplitude differs; with reverse balancing the amplitude is somewhat lower than with ordinary balancing when the amplitude of the recording depends little on the degree of deviation from the zero point.

The amplitude of the longitudinal rheogram recorded for the patient depends on the accuracy of establishing the electrodes on the artery. This must be expecially borne in mind when using small electrodes. If the electrode

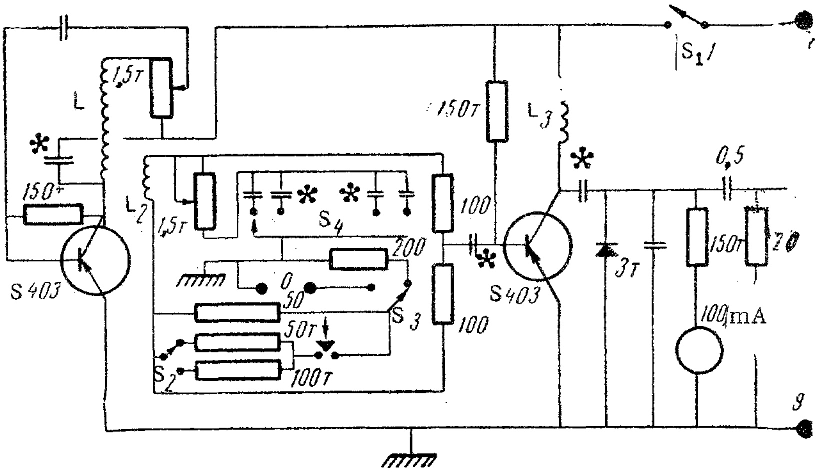

Fig. 1. Circuit of the semiconductor rheograph. The components marked by an asterisk are adjusted when tuning the instrument.

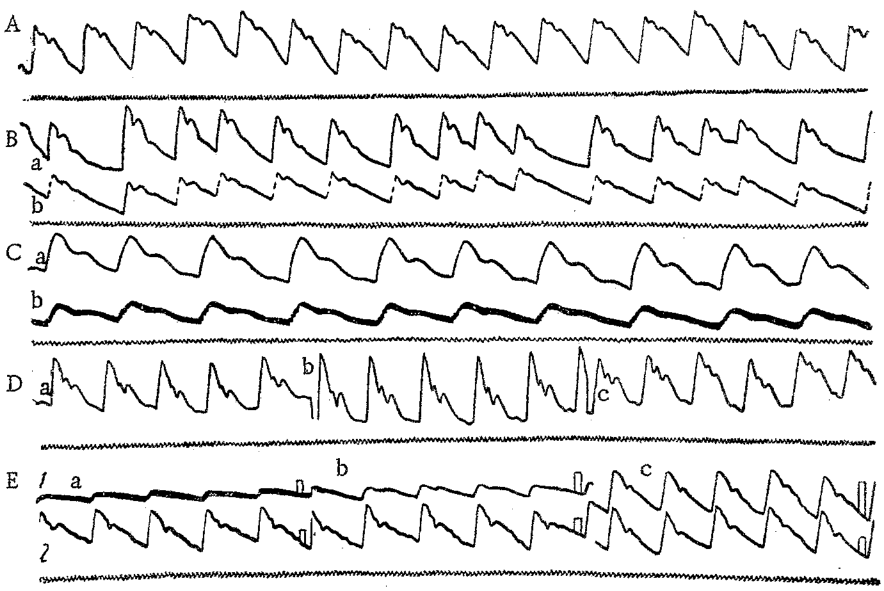

Fig. 2. Human rheograms and rheograms and sphygmograms of the isolated carotid artery of a dog: A) longitudinal rheogram of superficial temporal artery in healthy 23-year-old person; B) longitudinal rheogram (a) and sphygmogram (b) of isolated carotid artery of dog; C) transverse rheogram (a) and sphygmogram (b) of isolated carotid artery of dog; D) longitudinal rheogram of radial artery in 32-year-old person recorded at an interelectrode distance of 1 cm (a), 4 cm (b), 10 cm (c); the magnitude of the calibration impulse is the same for all three recordings; E) rheograms of symmetric portions of right (1) and left (2) superficial temporal arteries. The rheograms were recorded at a similar amplification (a), amplification on the right is increased, on the left as usual (b,c). The time marker under each curve is 0.02 sec.

is not accurately placed on the artery, not only the amplitude but also the shape of the recording is changed. When the electrodes are accurately established on the artery, the shape and amplitude of the recording do not depend on the size of the electrodes if the distance between them does not change.

When recording the transverse rheogram in the case of placing one electrode on the artery and the second on the opposite surface, the amplitude of the recording was less than with the longitudinal establishment of the electrodes. If the interelectrode distance becomes greater, the amplitude increases. By using large electrodes in transverse rheography, we can note an increase in the amplitude of the curve which is explained by the greater number of large vessels being between the electrodes. The same recording amplitude can be obtained if we use small electrodes, if they are accurately placed on large vessels. The advantage of small electrodes is that we can use them to study hemodynamics in a small portion of the body. A virtue of the rheographs we used is the possibility of balancing the instrument and obtaining a recording at a small interelectrode distance. Figure 2C shows a transverse rheogram of the isolated carotid artery of a dog. This recording in its shape coincides with the sphygmogram and longitudinal rheogram of this vessel. Thus, we can rheographically investigate hemodynamics not only in individual parts of the body, but also in an isolated blood vessel.

It was no less important to establish the effect of the interelectrode distance and the type of their fixation on the amplitude and shape of the rheograms. The amplitude of the rheogram of the isolated carotid artery of a dog depends on the distance between electrodes. Thus, if the interelectrode distance is 4 mm, the amplitude of the recording is 10 mm, at a distance of 10 mm it is 20 mm, and at a distance of 15mm, the amplitude is 25 mm. However, the configuration of the recording does not change.

We checked the effect of the interelectrode distance on the shape and amplitude of the longitudinal rheogram of the radial artery of patients. At an interelectrode distance of 1 cm, the amplitude of the recording was smaller than at a distance of 4 cm. However, upon increasing the distance to 10 cm, the amplitude dropped. This is explained by the fact that the electrode is established over a deeper artery and the muscle layer between the electrodes and radial artery is more massive. The shape of the recording at an interelectrode distance of 1 and 4 cm is virtually the same, but if the distance between electrodes is increased to 10 cm, unessential changes in the configuration of the recording are noted, as is seen in Fig. 2D.

When working with the rheograph, care should be given to the fixation of the electrode since not only the amplitude but also the shape of the recording depends on the degree of pressing. This was proved in an experiment on an isolated vessel with a gradual increase of pressure in the capsule pressing the electrode to the vessel. The contact between the electrodes and the skin is just as important. It is necessary to take into account that the gauze pad, soaked with a solution of sodium chloride, placed between the electrodes and the skin, can rapidly dry out, especially during a long recording, and this is reflected on the amplitude of the curve. In these cases, it is recommended to use a special paste which provides a reliable contact between electrodes and skin regardless of the duration of the recording. Improper fixation of the electrodes is one of the basic sources of errors when recording rheograms.

It is necessary that the amplitude of the curve be optimal. Only the recording of an optimal magnitude can be used for the characteristic of the shape of the curve. To elicit a pathological state, it is also necessary to record rheograms from symmetrical parts of the body at the same amplitude and compare their shape. Rheograms of symmetrical parts of the body having a different amplitude cannot be used for the characteristic of the shape of the curve. In this case, it is necessary to increase the amplification and bring the amplitude to the optimal. Figure 2E shows rheograms of both superficial temporal arteries, one having a smaller and the other a larger amplitude. It can be shown that the shape of both recordings is different. Thus, on the rheogram with the smaller amplitude, the apex is rounded off and the additional waves on the catacrotic limb are poorly evidenced. But an increase of the amplitude (with an increase of amplification) shows that the shape of both recordings does not substantially differ. It is only necessary to indicate the magnitude of the calibration pulse at which the optimal amplitude is obtained.

Our experimental data obtained in simultaneous recording of the rheo- and sphygmograms shows that the shape of both recordings is essentially the same and the curves completely coincide in time. Therefore, for an analysis of rheograms, we can use the same methods as for analysis of the sphygmograms.

An optical recording of the curves is needed to determine the standard values of individual indices of the rheogram and to perform the correct mathematical calculations.

LITERATURE CITED

1. A. D. Valtneris, Experimental Study of the Pulse Wave Propagation Rate, Candidate's Dissertation [in Russian], Riga (1962).
2. G. I. Éninya and P. A. Ondzuls, Byull. éksper. biol., 12, 105 (1961).