TECHNIQUE OF DETERMINING THE RATE OF PROPAGATION OF THE PULSE WAVE IN HUMANS AND ANIMALS

V. E. Busygin and Yu. G. Nefedov

(Received January 30, 1956. Presented by A. I. Nesterov, Member Acad. Med. Sci. USSR)

Valuable information about the function of the peripheral vascular system under clinical and experimental conditions may be derived from a study of the dynamics of the rate of propagation of the pulse wave.

The subject has been very little investigated up till now, however, chiefly because of the lack of simple and trustworthy apparatus for its measurement.

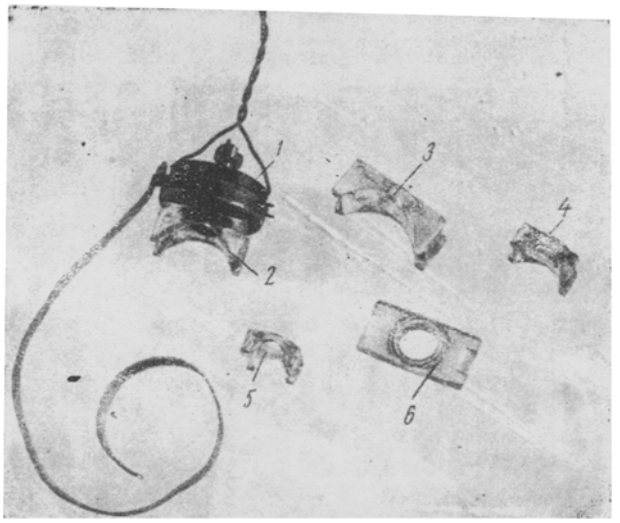

Fig. 1. Pulse recorder, with elastic tape for attachment, and a set of applicators for fixing the instrument. 1) ulse recorder; 2), 3) and 4) applicators for positioning the counter to the extremities: 5) applicator for the carotid artery, exteriorized in a skin tag; 6) for application to the chest.

We used pulse recorded designed by us, without amplifying arrangements [1], which provided a simple and readily available means of measuring the rate of propagation of the pulse wave. In order to register the time taken for a pulse wave to travel through a given section of the arterial system, or of an artery, tracings of the pulse wave were recorded at two or more points at various distances from the heart, with simultaneous recordings of a time marker. From the pulse tracings and the recordings of the time marker we derived the time taken for a pulse wave to travel between the selected points of the arterial system. Knowing this time, as well as the distance between the two reference points from which the pulse was recorded, we could calculate the velocity of propagation of the pulse wave over the given section of the arterial system.

The equipment for recording the rate of propagation of the pulse wave consisted of pulse counters, control panels, an electromagnetic oscillograph, and a time marker.

The pulse recorder is an ordinary carbon powder laryngophone, fitted with a cork disk fastened to a membrane. The recorder is fixed to the site where the pulse is to be measured. The way in which this is achieved depends on the location where the measurement is being made (Figures 1 and 2).

The control panel consists of a 4.5 volt battery (as used for a pocket torch), a resistance, from 400-700 ohms, and a switch. The circuit is shown diagrammatically in Figure 3.

The time marker, recording at 0.1 second intervals, consists basically of an electric motor, Type SD-60 (a synchronous electric motor, giving 60 r.p.m.), to the spindle of which is fastened an ebonite disk fitted with 10 brass contacts, with a fixed contact attached to the casing of the motor. Other designs of time marker may also be used. The electromagnetic oscillograph was of the usual design, with vibrators of a sensitivity of 5-10 mm per m. amp. The speed of travel of the photosensitive recording paper used for registration of pulse waves should be about 50-70 mm per second.

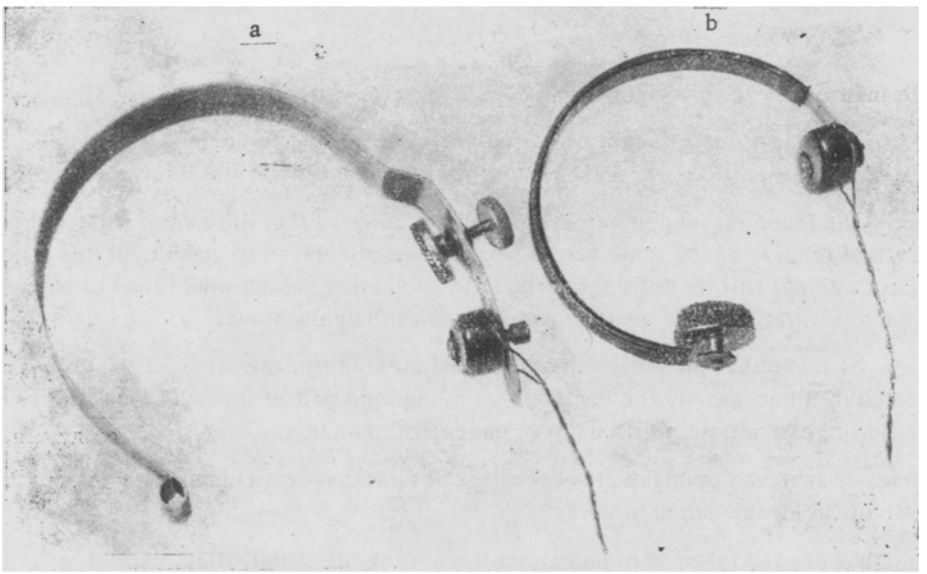

Fig. 2. Pulse recorders with a spring clamp, for registering pulse waves in human subjects. a) emporal artery; b) carotid artery.

The pulse recorders are fastened to the desired location, and are connected through the control panel to the vibrators of the oscillograph. The time marker is switched on in the same way, in connection with the corresponding vibrator (see Figure 3).

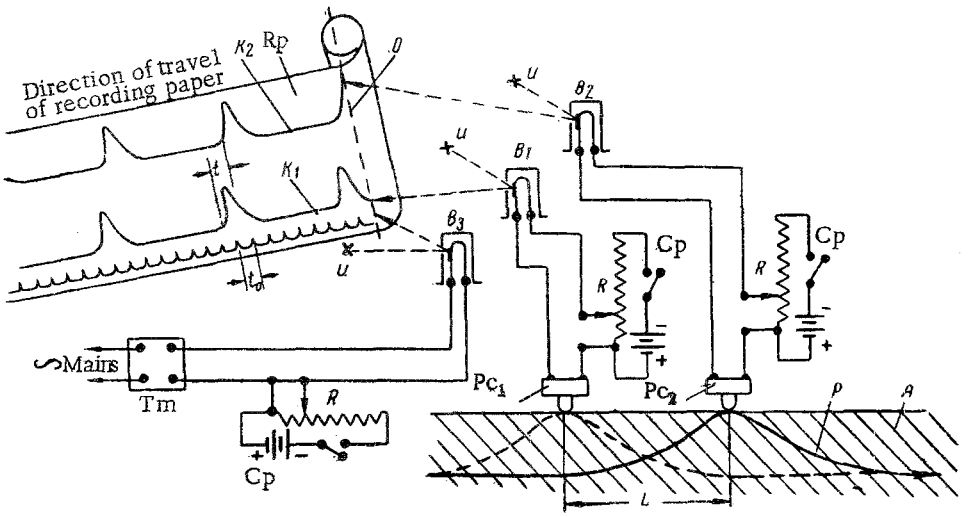

Fig. 3. Diagrammatic representation of registration of rate of propagation of the pulse wave. A) Artery; P) pulse wave; Pc_1) and Pc_2) pulse recorders; L) distance between pulse counters along an artery; Cp) control panel; R) variable resistance, for measuring the amplitude of tracings; B_1, B_2, B_3) vibrators; u) light source; Rp) recording paper; K_1 and K_2) tracings of pulse waves; Tm) time marker; t_0) time interval; t) time needed for propagation of pulse wave from one to the other counter.

Recording the rate of propagation of the pulse wave consists of the following. The pulse wave P proceeding along the artery A acts successively on the pulse recorders Pc_1 and Pc_2, changing their electrical resistance. The passage of the pulse wave along the artery A is recorded, as tracings K_1 and K_2 on the photosensitive paper, with the aid of the corresponding vibrators B_1 and B_2. At the same time, the time marker Tm records time intervals (0.1 seconds) on the same paper.

The rate of propagation of the pulse wave is derived from the tracings by the following calculation:

$$v_p = \frac{L}{t},$$

where v_p is the velocity of propagation of the wave, in milliseconds, L is the distance between the two counters, along the artery, in meters, $\underline{t}$ is the distance, expressed as seconds, between the beginning of an upward wave in tracing K_1 and of the corresponding wave in K_2, read from the number of time intervals $t_0 = 0.1$ seconds.

Before beginning the recording, the vibrators should be so adjusted that the spot of reflected light thrown on the paper by each of them is on the same vertical line, perpendicular to its length. If this is not done, the ordinates of the pulse tracings will be shifted, relatively to each other, which would lead to considerable error in calculating the absolute value of the speed of propagation of the pulse wave.

Care should also be taken that the pulse waves recorded are of about the same amplitude, as otherwise it may be difficult to establish accurately the beginning of the upward part of the pulse waves. The amplitudes are regulated by adjusting the variable resistances in the control panels.

Greater accuracy is achieved by making 3-4 readings of $\underline{t}$, at different points of tracings K_1 and K_2, and using the arithmetic mean for the calculation.

Pulse wave tracings may be taken from human subjects, using the radial, iliac, carotid, or temporal arteries, as well as the digital arteries of the hands and feet; the heart beat can also be recorded. It is thus possible to determine the rate of propagation of the pulse wave separately for different sections of the arterial system, or, if an oscillograph with a large number of vibrators is available, simultaneously for the whole system.

For animals, we usually determine the rate of propagation of the pulse wave along the section: origin of the aorta (from recordings of the heart beat or from the electrocardiogram) – anterior calcaneal artery.

LITERATURE CITED

[1] Yu. G. Nefedov, V. E. Busygin and S. V. Levinsky, Byull. Eksptl. Biol. i Med., No. 5,(1953).

METHOD FOR DETERMINING THE CIRCULATING BLOOD VOLUME, FOR EXPERIMENTAL PURPOSES

Yu. G. Nefedov (Moscow)

(Received January 30, 1956. Presented by A. I. Nesterov, Member Acad. Med. Sci. USSR)

The circulating blood volume is one of the basic indicators of the condition of the hemodynamic function of the cardiovascular system. This volume is usually derived from measurements of the dilution of dyes introduced into the blood stream, usually Congo red or Evans blue. This technique cannot, however, be applied to the evaluation of circulating blood volume regularly over a prolonged period. The measurements cannot be repeated at shorter intervals than 6-7 days, since the dyes are retained in the blood for a long time.

There are also a number of methods for determination of blood volume based on gas analysis, but they are very time-consuming, and unsuitable for the execution of mass experiments.