A NEW RECORDING ELECTRICAL RETINAL ARTERY SPHYGMO-TONOMETER

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Many authors, such as Baillart, Magitot(4), Bliedung, Duke-Elder and others, maintained that the measurement of retinal artery pressure (R.A.P.) is important as the first step to study the intracerebral vascular conditions which have intimate relations to various cerebral diseases and also to catch the conditions of peripheral vessels as their representative artery.

The methods of the measurement of R.A.P. had been reported by Baillart, Bliedung(1), Kukan, Baumann(2,3) and others. In Japan, Uemura and Suga-numa(10) reported in 1934 a newly improved dynamometer after many experiments. Since then, no further progress was made. But even with the Uemura-Suga-numa's dynamometer some defects are still found in the procedure and in the construction of the instrument itself. The most important defect is in a fact that subjective view of the operator can not be avoided in drawing a conclusion. Therefore, an accurate measurement of R.A.P. was very difficult and almost hopeless even by an ophthalmologist or much more so by clinicians of other field, but only the limited number of skilled ophthalmologists could operate the instrument. The authors have tried to simplify the method of measurement and to eliminate the subjective errors. Recently, we believe that we succeeded in meeting these defects by constructing a new instrument which will be reported in the following papers. With the new instrument, the corneal pulsation is also recorded simultaneously, facilitating an analysis of the functional and organized disorders of the retinal artery. (Photograph)

METHOD OF MEASUREMENT

The principle of measurement is the same as that of Baillart's, Bliedung's Baumann's and Uemura-Suga-numa's method, namely the eyeball is pressed by a pressure applied from outside, hence the central retinal artery is indirectly pressed which shows thereby pulsation. Hitherto this pulsation has been studied with ophthalmoscope, but with our instrument the corneal pulsation which is

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propagated to the cornea from the artery is electrically caught and recorded, and also at the same time the pressure applied to raise the ocular tension is recorded. By the analysis of these records, the retinal artery pressure is calculated revealing the conditions of vessel wall from the pulse wave. There are two methods for catching the corneal pulsation:

1) At first, the lower end point of movable plunger is applied on the cornea and the pulsation of the movable plunger is transmitted directly to the transducer.

2) The corneal pulsation is transmitted to the transducer through the mediums such as the air or other media.

But according to our experiments, we found the latter method is superior to the former, because the handling is easy and the ratio of signal to noise is less. So we adapted the latter method. As the transducer, following methods can be considered.

1) The method of detecting as the changes of inductance.
2) " " " capacity.
3) " " " resistance.
4) " " " Piezo-effect.
5) The photo-electric transducer and electro-magnetic transducer.

As the propagated energy to the cornea is small, we have to catch the total corneal energies effectively. And also on account of the view point of the favorable ratio of signal to noise and easy handling, we utilized the Piezo-effect of Rochelle-Salt with air as transmitting medium.
THE CONSTRUCTION OF THE INSTRUMENT

A) The construction of Pick-up.

The pick-up consisted of the handpiece, pressure cylinder, and movable cylinder. The pressure cylinder contains two coils and springs. The movable cylinder holds a crystal and iron core. The funnel shaped eye-piece attached to corneal limbus is constructed with acetylacid plastic, so it is easily applied. When the funnel shaped eye-piece is attached on the eyeball and the pressure is applied with the handpiece, the relation of relative position between the coil and iron core attached in the pressure cylinder changes as a supporting spring is pressed with the pressure. As the result, reactance of one side of coil increases and the other decreases. At this time two coils connected to both sides of current bridge and those are balanced at the state of repose. When
the eyeball is pressed, the instrument catches the unbalanced voltage as the pressure signal voltage. This is the same method as the pick-up-head of the previously reported electronic tonometer. (Fig. 2) When the size of coil and iron core are selected as the liner relation between the voltages looked in the unbalanced current bridge and the applied pressure, the out-put meter shows the applied pressure on the linear relations. Also it shows the value of the blood pressure when the pressures value of the initial tension is graduated. The central retinal artery begin to pulsate by application of pressure and the pulsation is propagated to the cornea. The corneal pulsation changes the inner pressure in the funnel shaped eye-piece and the crystal is excited by the vibration of the diaphragma of the crystal through the air. The out-put voltage from the crystal is the pulse wave signal voltage of the retinal artery. In the manipulation of eye-piece the diaphragma is also displaced by the static pressure caused by the contact of eye-piece and cornea; to prevent this error, it is necessary to connect both sides of diaphragma with a capillary serving as a kind of low pass filter.

B) Construction of Amplifier and Recorder.

When we amplify the voltage occured by the crystal, it must be selected the long time-constant crystal, and the pressure wave form is not differentiated because the fundamental frequency would be almost one cycle a second. The amplifier as shown in Fig. 3 is constructed by connection of direct coupled amplifier of C-R type with time constant of two seconds. To eliminate the electrical induction interference the negative feed back put in, so that it has sufficient discriminating power to be able to record perfect E.C.G. without using the shielded room. On the side of in-put, the compensating circuit put in to differentiate the in-put pulsewave. This circuit is calculated from the some ten m Ω of inner resistance and 250 P.F. of inner capacity of the crystal.

RESULTS OF MEASUREMENT

The pulse wave which was recorded by this apparatus, is shown in Fig. 4. This recorded continuous pulse waves are able to be analysed into two waves, i.e. volume pulse wave and pressure pulse wave, and the point of the characteristic large pulse wave is thought to correspond to the minimum blood pressure and the point of disappearance of characteristic pulse wave is thought to correspond
to the maximum blood pressure. When the initial tension is standardized, the blood pressure value of the central retinal artery is able to be calculated. This calculated value shows higher figures than that measured at sitting posture by Uemura-Suganuma's instrument. But considering the increasing effect by sitting posture used in the latter method, the pressure value shows approximately the same value. (Fig. 5)

As above mentioned, we get two pulse waves, i.e. volume pulse wave and pressure pulse wave. The first is the pulse wave which is to be understood easily when we think of the eye as a pletysmograph, namely the wave aroused by contacting the eye. The second is the pulse wave which is produced by as think the eye as a sphygmograph and the retinal artery pulsates on account of the compression. The respiration influences to the volume pulse wave largely. By this results, there appears a higher peak wave, a contrary higher reacting eleva-
tion wave or an echelon form wave. These waves piled up on the respiratory wave. (Fig. 6 a.b.c.)

Fig. 6 Volume puls wave

a. Higher peak  
b. Echelon form wave  
c. Higher reacting wave

Fig. 7a. Pressure puls wave of normal person

a. Lower pressure  
b. Higher pressure

Fig. 7b. Pressure puls wave of retinal angiospasmus patient

a. Lower pressure  
b. Higher pressure

Fig. 7c. Pressure wave of retinal artery sclerosis patient

a. Lower pressure  
b. Higher pressure

Fig. 8 Sharped wave appeared near the end of pressure puls wave
On the pressure pulse wave regardless of different physical character of eye component such as eyeball wall, lens, glassbody and etc., the reacting elevation is hardly shown. We found only the simple pulse wave and the backward movement of the peak alongside with the increase of applied outer pressure, and the influence of respiration is relatively small in this instance.

Between retinal angiospasmus and retinal artery sclerosis, the pulse wave form and including wave elements are found somewhat different. (Fig. 7 a.b.c.) The sharpened and flat waves appear near the end of pressure pulse wave which is thought to be aroused by the influence of A. Ophthalmica. (Fig. 8)

CONCLUSIONS

1) A new recording electrical retinal artery sphygmo-tonometer was constructed for the purpose of simplification of technic and elimination of subjective error for the measurement of retinal pressure.

2) The contral retinal artery pressure value measured by this instrument was almost the same as the value of Uemura-Suganuma's instrument when considered the influence of the posture.

3) With the recorded pulse wave, we differentiated two waves, i.e. the volume and pressure pulse waves. Among various diseases, we found some differences on pressure pulse waves.

4) We found the evidence that the minimum blood pressure of A. Ophthalmica is close to or covered with the maximum retinal artery blood pressure.
BIBLIOGRAPHIES


