THE USE OF ORBITAL PLETHYSMOGRAPHY TO STUDY THE REGIONAL CEREBRAL CIRCULATION IN HEALTHY PERSONS

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The reactivity of the orbital and peripheral blood vessels in healthy persons in response to unconditioned stimuli and pharmacological agents was studied by plethysmography and rheoencephalography. In healthy persons a parallel is observed between changes in the orbital plethysmograms and rheoencephalograms under the influence of papaverine, distinguishing between the trend of changes in the orbital and peripheral vessels in response to the action of carbon dioxide and other pharmacological agents, while various unconditioned stimuli have no effect on the tone of the orbital vessels.

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Most clinical physiological methods of investigation of the cerebral circulation widely used at the present time can give only an indirect idea of the state of the blood vessels of the brain. The method of rheoencephalography has been shown to be of potential value.

Plethysmography is a highly sensitive method of investigation of the circulatory system. In 1952, Votchal [3] in the USSR and Malec and Peter in Czechoslovakia [4, 5, 6, 7] suggested a method of recording pulse waves in the orbit, i.e., orbital plethysmography, for the study of the cerebral circulation.

In the present investigation the reactivity of the orbital and peripheral vessels of healthy persons at rest and in response to unconditioned stimuli and pharmacological agents was studied by plethysmography. The action of pharmacological agents on the cerebral circulation of some subjects was also tested by rheoencephalography.

EXPERIMENTAL METHOD AND RESULTS

Tests were carried out on 52 persons (20 women and 32 men, of whom 9 were under 30 years old, 8 from 31-40 years, 18 from 41-50 years, and 17 persons were over 52 years old).

Plethysmographic studies were carried out with the 2-channel plethysmograph manufactured by the All-Union Research Institute of Medical Instrumentation, providing synchronized recording of the orbital and digital plethysmograms (DP) or orbital plethysmograms (OP) on both sides.

As a rule the same subject was examined twice or three times. Besides recordings of the background plethysmograms, function tests (immersing the hands in cold water for 1 min, acoustic and electrodermal stimulation, mental arithmetic) and also tests in which air with an increased carbon dioxide concentration (10-12%) was inhaled for 2-3 min, pure oxygen was inhaled, or 2 ml of 2% papaverine solution was injected intravenously and one or two drops of glyceryl trinitrin were applied beneath the tongue, were carried out on most subjects. In addition, a test was used in which the cervical veins were compressed, indicating the venous tone of the cerebral vessels [2]. Altogether 186 plethysmographic investigations were carried out.

The results showed that in most healthy persons (46 of the 52 subjects) a zero OP background exists which is usually established toward the end of the first or second test. The DP of most healthy subjects likewise had a zero background. As a rule, the pulse waves of the OP and DP were dicrotic in form.

The plethysmographic curves from both orbits were symmetrical in all healthy subjects. The test with compression of the cervical veins caused a bucket-handle type of increase in OP in 4 subjects only, and had no effect on the plethysmogram of the others. When the hands were immersed in cold water, or

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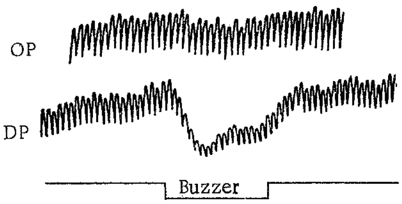

Fig. 1. Responses of orbital vessels (OP) and digital vessels (DP) to acoustic stimulation.

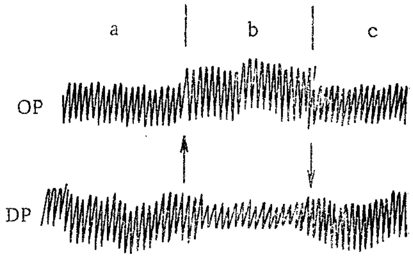

Fig. 2. Effect of inhalation of air with an increased carbon dioxide concentration on the orbital (OP) and digital vessels (DP). a) Initial curve; b) during inhalation of CO_2; c) after end of inhalation.

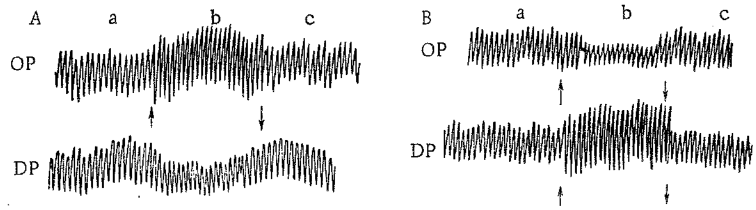

Fig. 3. Effect of papaverine (A) and glyceryl trinitrin (B) on orbital (OP) and digital (DP) vessels. a) Initial curves; b) after injection of papaverine or glyceryl trinitrin; c) recovery of initial form of curves.

during application of acoustic and electrodermal stimulation, the DP of nearly all subjects showed a definite spastic response with "bucket-handle" formation and a decrease in amplitude of the pulse waves, whereas the OP showed no changes (Fig. 1). Mental arithmetic caused a decrease in amplitude of the pulse waves on the DP in 42 subjects, but on the OP in only 3 subjects. In 8 subjects mental arithmetic caused distortion of the zero OP background which became fluctuating, with the appearance of respiratory waves.

The fact that contact and distant unconditioned stimuli (cold, acoustic and electrodermal stimuli), like mental exertion (mental arithmetic), although producing a distinct response of the peripheral blood vessels, had no significant effect on the orbital vessels confirms, in my opinion, the identity between responses of the orbital vessels and those of the cerebral vessels. The cerebral arteries are known to possess lower nervous-reflex excitability than the arteries elsewhere in the body [1, 4, 5, 9].

Inhalation of air with an increased concentration of carbon dioxide caused an increase in amplitude of the pulse waves of the OP in most subjects by 25-40% (with extreme fluctuations of 25-120%), an increase in amplitude of the rheoencephalogram (REG), and a simultaneous decrease in amplitude of the DP (Fig. 2).

Inhalation of pure oxygen caused a small (by 5-15%) decrease in amplitude of the pulse waves of the OP but had no significant effect on the DP. Hemodynamic changes of a similar pattern in the cerebral and peripheral circulation under the influence of the same physiological stimuli have been established by other methods [4, 8].

Intravenous injection of 2 ml 2% papaverine solution increased the amplitude of the OP to a greater degree (by 30-50%) than inhalation of increased concentrations of carbon dioxide, and also was accompanied by some increase in amplitude of the BP (Fig. 3A). The vasodilator effect of papaverine on the orbital vessels lasted about 2-3 min. During this time an increase in amplitude of the REG by 1.5-2 times was observed.

Besides increasing the dicrotic waves, in most healthy subjects glyceryl trinitrin considerably decreased the amplitude of the pulse waves of the OP, while the amplitude of the DP waves was always increased by 50-100% (Fig. 3B). Meanwhile, glyceryl trinitrin consistently increased the amplitude of the REG.

In my opinion the decrease in amplitude of the OP waves produced by glyceryl trinitrin can be explained by the action of this drug on the venous system of the head and brain and, in particular, by the effects of transient venous stasis resulting from atony of the veins.

The parallel between the changes in OP and REG thus established in the experiments with papaverine, the different trends of the changes in OP and DP in response to the action of carbon dioxide and other pharmacological agents, and the absence of effect of some unconditioned stimuli on the tone of the orbital vessels all served to confirm the value of the method of orbital plethysmography for the study of the human cerebral circulation.

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