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DYNAMIC EVALUATION OF FUNCTIONAL CONDITION OF THE MECHANISM PROMOTING THE CIRCULATORY-METABOLIC SUPPORT OF HUMAN BRAIN ACTIVITY

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The estimation of the functional state of the physiological mechanism, responsible for the circulatory-metabolic supporting of brain activity, is of interest for many aims. This is important for the timely evaluation of influence of environmental factors, such as industrial process conditions, on brain blood supply. The urgency of the latter increases constantly, so far as the introduction of new technologies inevitably follows by the changes in the environment conditions.

This, in turn, can result in undesirable and even dangerous consequences, caused by so- called "human factor". In this case, the mechanism of the circulatory providing of brain activity plays separately important role, since it determines not only a worker's feeling and health, but also it can influence the quality of his professional activity. The problem is of important also for medicine, particularly in neurology and neurosurgery, when it is critically important to estimate, accurately and dynamically, the brain blood supplying.

At the same time, the operational and timely estimation of functional changes of mechanism of circulatory-metabolic providing of brain activity is a complex problem.

The fact is that there is no universal method for this aim up to now, and therefore it is necessary to adopt the specially selected combination of routine procedures to obtain the reliable and dynamic information. One should also take into consideration that such studies must be maximally adapted to real industrial conditions as the investigations should not substantially hinder a worker in his production process.

Among the known and reliable experimental approaches which most fully correspond to such requirements, there are two methods, each of them are proved oneself as effective in the clinical practice - the transcranial dopplerography (TCDG) and rheoencephalography (REG). The first makes it possible to record the dynamics of linear blood flow velocity in the large cerebral arteries, and the second reflects the change of relations between blood and cerebrospinal fluid (CSF) volumes within the selected intracranial region.

Taking into account the special features of interaction between volumes and pressures of liquid components (arterial, venous blood and CSF) in the craniospinal cavity as well as active processes in the system of cerebral blood circulation, it is reasonable to study the relationships between changes of TCDG and REG in the time-limits of one cardiac cycle.

In this case the estimation of role of various factors in the mechanisms investigated is based on the comparative analysis of the cardiac cycles at different states of the organism - at rest and during hemo- and liquorodynamic functional tests. Such approach makes it possible to reveal the concealed changes in the functioning of the systems, responsible for circulatory- metabolic supporting of brain activity.

Biophysical and experimental studies of TCDG and REG dynamics during a cardiac cycle allow, in high probability, to conclude that TCDG changes are similar to changes of intracranial pressure (ΔP), while REG changes reflect the volume changes (ΔV) of liquid media in the investigated intracranial region. If TCDG probe focuses on base fragment of middle cerebral artery (MCA), while REG electrodes are positioned fronto-mastoidally, the region under investigation will cover the significant brain zone supplied by MCA.

The analysis of relationship between hemo- and liquorodynamics during one cardiac cycle is interesting because as during this period the increment of intracranial blood volume is about 40% of stroke volume which comes to the cranium. The low tensile cranium must intake additional blood volume during systolic increase of arterial pressure, and decrease of pulse blood volume gain leads to

reduction of cerebral circulation, and even relative small volumetric changes are of important. In fact, total brain blood flow is about 600ml per minute, so during a cardiac cycle about 10 ml of blood pass through the brain, while 4ml is the systolic volume intracranial increment for ca. 0,15 -0,25 s. This does mean that reduction of this blood volume increment only by 1 ml - i.e., 0,07-0,1% of average brain volume (ca. 1200 ml) - can lead to reduction in cerebral blood flow approximately to 8-10% which is of physiological significance.

It is obvious that this additional intracranial blood volume will is influenced by several factors: tensibility of cranium as a biomechanical system, CSF shifts between cranium and spinal cavities, redistribution between arterial and venous blood volumes. Therefore the analysis of the simultaneously registed pulse changes of TCDG and REG is directed toward the evaluation of role of these factors taking into account the average cerebral blood (CBF). This can be done by means of pattern and phase analyses of simultaneously registered TCDG and REG and by use of "MultiDop- P" and "RG4-02" instruments, interface "PowerLab-4" on PC "Macintosh OS -10.4.2" with wide program possibilities, especially "Chart-5.1", "Canvas-10". This makes it possible to reveal and estimate the indices of brain blood supply:

- cranium pulse tensility (compliance) which corresponds to $\Delta Ve/\Delta Pe$ ratio during the initial phase of cardiac cycle (Cce index);
- pulse CSF mobility in the middle phase of cardiac cycle when $\Delta V/\Delta P$ correlation is disturbed because of the CSF shifts which can be described as ($\Delta Vc \times \Delta Pc$) - index CCc;
- pulse blood outflow from the cranium during last phase of cardiac cycle when interrelation between ΔVo and ΔPo is restored and can be determined as $\Delta Vo/\Delta Po$ (index CCo).

The investigation of healthy persons aged 25 - 70 years revealed that the values of these indices, as physiological standard, are: CCe 0,8-1,1; CCc 0,25-0,45; and CCo 1,5-2,5. If the indices are decreased it can be regarded as the sign of cerebral circulatory insufficiency; the increase of the indices is unlikely and is a sign of serious pathology.

To consider these indices as reliable sign in evaluation of cerebral blood flow decrease it is necessary to compare them with some integral index which could summarize the quality of brain activity. It might be the index of prognostic brain ability (PBA), which reflects the highest forms of brain functioning and is determined by the human intellectual possibilities. Therefore, PBA can be considered as the final index of the functional state of mechanism responsible for the circulatory-metabolic brain support.

For evaluation of PAB the optimal method, in our view, is the psychological test "Prognosis-1", which well presented itself in a number of investigations. This procedure is sufficiently valid, reliable and allows to define the type of human prognostic activity in 10 minutes. For the estimation of correlation PAB to indices CCe, CCc, CCo and CBF, the comparative-aging investigations were carried out. In the group of 40-50 years with normal CBF was shown, that in persons with decreased PAB the decrease of CCe to 0,6 and CCc to 0,12-0,18 was observed, while CCo was not changed significantly. In elder age group (above 70 years) an initial decrease of PAB was accompanied by drop of CBF by 20-30%, CCe to 0,7 and CCc to 0,15-0,20. The expressed decrease of PAB with the similar drop of CBF was noted, if CCe was less 0,6 and CCc less 0,10-0,15. According to the results of functional tests it is possible to assume that under some professional loadings, which impede venous outflow from the cranium, the complicated hemo-liquorodynamic situation can lead to decrease of PAB. A similar result can be also connected with the change of environmental gaseous composition, contamination of air with some chemicals, and under action of stress-factors.

Thus, the dynamic evaluation of functional state of mechanism, providing the circulatory-metabolic support of brain activity, which can be carried out by complex measurements of cerebral blood flow, hemo-liquorodynamics and biomechanical state of cranium, is not only of high medico-clinical value, but can be of informative for dynamic observation of negative influences of industrial conditions on worker's ability. It is very probable that the influence of each separately factor can be insignificant, but their randomly appearing combinations, especially if they moreover are accompanied by stress, result in substantial increase the risk of PAB decrease as a component of so called "human factor".

If take into consideration these circumstances it will be possible to decrease the risk of undesirable consequences, connected with progress of industrial high technologies.