International Journal of Biomedicine 1(4) (2011) 245-248

INTERNATIONAL JOURNAL OF BIOMEDICINE

Point of View

Intracranial Venous Pressure as a Possible Determinant of Mental Regulation

Alexander G. Kruglov, PhD, ScD, Georgiy Y. Gebel, PhD, ScD†, Alexander Y. Vasilyev, PhD, ScD*

Moscow State University of Medicine and Dentistry, Moscow, Russian Federation

Abstract

The article deals with the mechanisms of cerebral venous blood flow (CVB). CVB is discussed as the equivalent of initiation of neuron chain activity, providing the mental activity of a person. Venous cerebral hemodynamics and the activity of neuron chains are considered as synergistic components of the mechanism of target achievement through the information determination of physiologic processes. The concept of *"motivation gradient"* (MG) is introduced, as a vector initiator of self-regulation, with a difference in sample parameters in starting (present) and final (target) stages. Decreasing subjective temporal flow is argued to have an opposite vector to MG. It reaches the zero value at the point of parametric alignment of MG. As imbalance, a feeling of dissatisfaction and other deficit problems, i.e. gradient conditions, may develop through the full spectrum of requirements (physical, social, etc), the concept of MG is proposed for usage in a wide range of applications, both in physiology and in psychology. IJBM 2011; 1(4):245-248.

Key words: *target, information determination, neuron chains, cerebral venous blood flow, motivation gradient, adaptable dynamic, subjective time, parametric alignment, homeostatic balance.*

Mechanisms of intracranial pressure (ICP) formation in humans and its dependence on arterial (BP), venous (VP), capillary and liquor (LP) pressures have been studied for many decades. The influence of factors determining the level and fluctuations in ICP is limited to the change of ratio between the volumes of the components occupying the cranial cavity. Changes of their total volume cause shifts of LP. Liquor is the transmission link between arterial, venous vessels and the elements of brain tissue. Cerebral blood flow (CBF), which provides adequate brain activity, is changed only when the LP exceeds the VP, after which the CBF is reduced proportionally to the rise in BP causing violations of the brain activity.

Regarding the regulation of cerebral venous blood flow, opinions are different, from denying the influence of venous blood flow on CBF in normal conditions to suggesting the prevalence of neural influences serving the system requirements; or to the dependence on blood flow in the exchange field of the brain, etc. Several authors [1, 4, 9] experimentally confirmed the dependence of cerebral circulation on venous circulation, highlighting the uncertainty of regulatory mechanisms of these processes. V A Shidlovsky et al., 1979 [7] experimentally confirmed the data obtained from the model and showed that the most effective effector link is venous elasticity, causing the greatest change of functions (pressure, blood flow, blood volume) in three subsystems: arterial reservoir, heart, venous system. The range of views of researchers on the relationship between pressures (VP-LP) in the brain tissue is narrow: from full compliance of LP and the VPs to exceeding of VP in the brain veins in relation to the LP, but with a lower level of VP in the brain sinuses. The dependence of the critical value of VP on the ratio of wall thickness to the radius of the vessel and the modulus of elasticity of the wall has been shown [5]. Even with a small predominance of external pressure over internal (0.2-0.5 mm Hg), stability of the veins is lost, and their lumen changes abruptly. An increase in ICP causes transformation of intracerebral vein lumen from circle to oval-shaped, and then to a slit-like shape. With rising ICP and the exceeding of the VP the vessel is collapsed, the inner lumen of a vein is closed, followed by cessation of venous flow in the microcirculatory bed and the

**Corresponding author: Prof. Alexander Y. Vasilyev, PhD, ScD, Head of Radiology Department, Moscow State University of Medicine and Dentistry, 15 Aviaconstructor Mil str., housing 1, apt. 70, 109431, Moscow, Russian Federation.*

Tel: 7-495-6110177 E-mail: auv62@mail.ru

oppression of metabolism in the brain tissues.

In the concept presented the venous blood flow in the brain tissue is regarded as a hemodynamic, bio-physical component of the interdependent, synergistic mechanisms of mental activity that provide the functional associations of neural networks, and metabolic supply to activated neurons. Note that the cell bodies of neurons, occupying about 5% of the cerebral cortex, consume 25% of all the oxygen supply, which must be covered by an adequate volume of CBF as early as in the first phase of functional hyperemia. Excited neurons with subsequent transition to an active state of elements, united in a functional circuit, require metabolic processes; increase the volume of inflowing blood, which happens only due to changes in the inner lumen of the cortical artery with no possibility of changing its outside diameter that would lead to compression of elements surrounding the brain tissue. Note that the amplitude of cortical arteries lumen changes increases with a decrease in their caliber. Volumetric blood flow in the smaller size vessels is also increased due to the Fahraeus-Lindquist effect, lowering blood viscosity. Microcirculation increases due to the transition of plasma capillaries to a state allowing an increased number of active capillaries. There are four regulatory circuits of CBF: neurogenic, humoral, metabolic, and myogenic, and priority is given to the circuit most suited to the situation.

Discussion

Purpose of this work: definition of theory model with regard to interrelation of CBF in the microcirculatory bloodstream and initiation of psychic regulation in human under normal conditions. The subject of the study was the hemodynamic and biophysical equivalent of metabolic supply of activated neural circuits, i.e. initiated and lasting mental activity.

Postcapillary venules and brain veins are a special interest in the proposed concept as they have a central place in the scheme, uniting the effector component of mental activity (functional association of activated neurons) and hemodynamic gradient (vector of ratio of LP to VP). Parameters of VP and CSF pressure are well known and have no significance for our study. The main subject of discussion is the dynamics of gradient venous relations between two liquid media, that is human intracerebral venous blood and liquor fluid under normal conditions, in the context of neural network activity onset and metabolic provision. Brain veins have a thin wall consisting of one-two layers of endothelium and of connective tissue layer without elastic and muscular plexus.

It seems that the intracerebral veins normally can operate in two states:

1. When neurons in the metabolic field served are activated (maximum blood supply): intravascular pressure is higher than LP; circular vein section;

2. In resting neurons, with a minimum metabolic level (minimal blood supply): intravascular pressure is equal to the LP; section of vein is oval, slit.

Thus, if any activity occurs in the metabolic field, i.e., during excitation of neurons in the averting vessel, even in the first phase of functional hyperemia, due to the increased volume of local blood flow intravascular pressure increases. Vein, increasing in volume, takes a cylindrical shape, reaching its maximum permeability (with a circular cross section).

Intracranial space is closed for fast processes (initiated in less than one cardiac cycle) due to hydraulic resistance to redistribution of fluid volumes [3]. At the same time, in the intracranial space a balance exists between the amount of brain substance, of cerebrospinal fluid, and of blood [2, 3].

Excessive pressure of the intracerebral veins, which increase in volume, spread through the cerebrospinal fluid spherically along the activated neural circuit, can be utilized in the incompressible – non-displaced space by only one structure – **intracerebral veins**, which are not involved in the metabolic supply of the activated neural circuit. For the period of excess LP the transmural pressure from outside the wall of uninvolved veins increases, with an increase of intravascular pressure and compensatory outflow by the pressure gradient and change in cross section of the vein (oval – slit-like shape), and with a decrease of the **volume** capacity. Thereby, retaining VP increases in the functional microvasculature unit (backwards): vein → postcapillary venule → capillary → precapillary arteriole → arteriole. Therefore, integration of the mechanisms for the metabolic securing of initiation of the neurons involved in other non-activated neural associations is complicated. Thus, the hemodynamic biophysical gradient effect of the actualized neural circuit in the attainable radius of influence leads to difficulty in initiating the metabolic securing of initiation of non-activated neural circuits, creating a competitive environment, and increasing the threshold of neuron excitability. At the same time, the vascular network, with maximal volume of blood flow due to the lasting activity of the neural circuit, causes excessive pressure and is less vulnerable to external pressor effects. Perhaps this is the hemodynamic equivalent of reverberation and other continuing conditions, as well as of neural structures that ensure vital functions. We believe that the first stages of initiated mental activity in the brain tissue, realized by actualized neural circuits, develop the biophysical phenomenon of excessive pressure (non-pulsating, non-cardiac) as a wave dissipative structure, spherically spreading through the liquor fluid. It is creating priority energy supply of activated neural circuits, counteracting other initiations, interfering with the wave consequences of active neural structures with sufficient energy supply.

The activity of neurons reflects their involvement in a system with the organization of all processes as the informational equivalent of the result, i.e. of the future event [8], where the mental factor acts as a systemic quality of the organization of physiological processes. Thus, the activity of neurons in the behavioral act system means that the behavior contains the mental, i.e., informational determination of the physiological mechanisms through system processes. During the behavioral act, which has a hierarchical, gradient structure (for example, the implementation of a **need** as the most significant of the dispositions that supports purposeful activity to meet the need), the mental activity serves as a determinant of initiation and lasting activity of neural circuits, which in turn is a determinant of metabolic

processes, determining the volumetric hemodynamic phenomenon, which is an antagonist of other initiations at the time (that is a measure of the relevance of **motive**) of the behavioral act's existence. It should be emphasized that the cooperative (synergism – antagonism) regulation of the functional system described acts in a series of deterministic gradient subsystems: **psyche → neural associations → exchange field, metabolism → increase volume of CBF → overpressure → psyche**, where deactualization of a **motive** ceases the activity of the effector mechanisms.

Motive, as a stable property of the subject, motive force, the reason for his behavior, is a set of dispositions, the most important of which is a **need** [8]. Need is considered as a state of dissatisfaction of the body (the person), lack of what is required to maintain a state of homeostatic equilibrium of the body (the person). A feature of a live being is a selective character of response to the subject of actual **need**, to address the imbalance, i.e. to eliminate the gradient: the present state – the target state. The result, for which the activity is undertaken, is defined as – the purpose, the mental image of the future result, formed by the subject, and is a major part of a deliberate regulatory process. The goal, that is the mental image, possessing the model characteristics and being a perceived determinant of behavior, forms the entire process of self-regulation as a **vector with a difference of model parameters between the initial (present) and final (target) phases.**

We create relations medium-individual under conditions of interoceptive fixation of metabolic, psychological deviation, misbalance, followed by inclusion of homeostatic, behavioral correction as a state when the goal (future) state is more preferable than the present one. That is the difference between the present and the future states, whatever it is represented through (Na blood plasma concentration or stages of career path), defines the values of the goal state and its achievement vector. This very difference in the values of the goal and the present states of a subject that initiates homeostatic correction is identified as **"motivation gradient"** (MG). It initiates and actualizes goal-oriented behavior forms. Their end goal is to achieve the parametric equalization, i.e. elimination of the motivational gradient. Thus, the MG stimulates the body (the person) to find the needed object to correct the imbalance, to restore the homeostatic equilibrium, i.e. to eliminate the MG. Since imbalance, frustration and other forms of deficit, i.e. gradient states, in humans may occur across the full spectrum of needs (physical, spiritual, social, etc.), it is possible to use the term MG in its broadest application, both in physiology and in human psychology.

Considering homeostasis as the constancy of the parameters of the internal environment while the parameters of the environment are changed, the organism is regarded as a self-regulating system that tends to maintain a state of current balance, for physiological as well as for psychological parameters.

Targeted behavioral acts of any complexity and duration are aimed to meet the actualized **need**, that is, to remove the MG, have a hierarchical, gradient structure, and determine initiation and lasting activity of neural circuits; the discussed hemodynamic, biophysical gradient of the cerebral venous bed is the equivalent of their activity. Thus, the MG, which has model characteristics in the form of a gradient of parameters of correlative – correlated operational patterns, has a consistent hemodynamic gradient (VP – LP in brain tissue) of actualized neural circuits that have morpho-physiological characteristics. Hemodynamic gradient emergence mechanism we described, irrespective of localization, is not available for invasive studying techniques, which we have been applying, in cerebral probing in human. We believe that our theory can be verified by means of functional MRI. There have been no subject-related materials found in available reading matter.

Initiation and duration of the existence of the MG and equivalent hemodynamic gradient are determined by actualization of the motive and by achievement of the target state because of purposeful behavior. Considering the MG as a characteristic that indicates the direction of steepest change in the scalar variables, whose value varies from one point in space to another, we define the zero (starting) point of subjective time (ST) for the image of the target, which can be taken in psychological time as an abstract point, while the present is always a certain time interval [6] (in contrast to Husserl, who determined the zero point of ST at the stage: Now, currently). That image of the target is the psycho-physiological stimulus for MG formation and the starting point for the formation of an interim assessment scale for the rate of result achievement (ST). In pursuit of the goal, forward movement on the MG thus means movement along the descending ST (time perspective) to the mark 0. Thus, we can assume that decreasing ST flow (the initiation, duration and staged rate of which are determined by the relevance of motive and by motivation) has a vector that is opposite to the vectors of MG and of increasing quantities (physical, biological) of time, reaching a zero value at the point of parametric equalization of the MG.

In the sequence, described ST flow is only possible if some events occur in the subjective world (whose nature is irrelevant: perceptual, motor, cognitive events). The experimentally confirmed dependence of subjective length of time from occupancy (subjectively shorter) to non-occupancy (subjectively long) by events; 5-fold excess density of ST in a 10-year old child, compared to a 60-year -old man, let us directly correlate the subjective sensation of speed of living life (time flow) with the total number of subjective events (density, saturation). As the subject gets older, accumulates automated skills, fills the memory resources, he creates, in addition to many short-term, often stereotyped tactical aims, several forward-looking plans for achieving long-term strategic aims, covering large time intervals. The structure of the MG and ST for strategic purposes (as opposed to tactical ones) is discrete in the sense that the phenomena that are accompanied by changes of parameters may occur at periods separated by time intervals, while being in the narrative directed sequence of events.

Upon reaching a strategic target, the ST is reset, with parametric equalization, that means the end of the motivation that initiated the MG, which is retrospectively perceived as a fused experienced event, regardless of the time actually lived. Motivational incentives in terms of strategic planning, forming the corresponding targets-images, determine the ST flow for a considerable length of

time in discrete conditions, therefore, the current, present (filled largely by automated stereotypical actions) ST is perceived as less filled, slowed, while the time of the goal achievement, zeroing of ST, is subjectively experienced as a quickly reached, tactical one.

We believe that the retrospective assessment of ST speed is subjectively quantized by event-driven narratives, smoothing the real times of achieving of tactical and strategic purposes.

Conclusions

Initiation and duration of the existence of the MG and equivalent hemodynamics gradient are determined by actualization of the motive and by achievement of the target state because of purposeful behavior. The lifetime (from the beginning to the disappearance) of a MG creates a subjective feeling of movement of ST. There is no prolonged state of stable present for a subject. Motivating by variable goal images due to metabolic and psychic deviations, misbalance, the subject is persistently in the vector space of motivational gradients of goals achieved one by one. The goals images (the future) actualize subject's adaptation dynamics. The present represents only a temporary pretension and is manifested by emotional connotation (+, 0, -) depending on matching-mismatching of subject's actual state with estimated waiting of parametric equalization, state of homeostatic balance.

References

1. Labory A. Regulation of metabolic processes. Moscow: Medicine, 1980.
2. Lerman VP. Cerebral circulatory disorders in intracranial tumors. Minsk, 1976.
3. Moskalenko YE , Weinstein GB, Demchenko IT, Kislyakov YY, Krivchenko AI. Intracranial hemodynamics. Leningrad: Nauka, 1975.
4. Moskalenko YE, Weinstein HB. The role of intracranial veins in the cerebral blood flow regulation mechanism. In: Proceeds of the international symposium on the regulation of capacitative vessels. Moscow: Medicine, 1977. p 120-129.
5. Moskalenko YE. Functional stability of the cerebral circulation. Physiological Journal, 1978; 64:589-597.
6. Rubinstein SL. Fundamentals of General Psychology. Saint Petersburg: Piter, 2003.
7. Shidlovsky VA, Vezloyaschev DV, Lischuk VA, Ledenev VI, Nelyudova IV, Sadoyan DG. Biophysical properties of an isolated cardiovascular system. Krovoobraschenije, 1976; 5: 29-36.
8. Shvyrkov VB. Introduction to objective psychology. Neural basis of psychology. Moscow: Moscow Institute of Psychology of RAS, 1995.
9. Tkachenko BI. Venous circulation. Leningrad, 1979.