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Principles of Somatopsychic Regulation of the Homeostatic Continuum of Homo Sapiens

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Abstract: Placental mammals are considered fluid biological systems that begin to function in a gaseous environment once they reach the intrapartum stage. The fundamental principle underlying the functioning of a biological organism is the creation and maintenance of homeostatic equilibrium by the psyche. Both the external environment and the internal organs are treated as external objects in relation to the psyche. Haemodynamic and metabolic parameters obtained via catheterisation and processed mathematically were consolidated into an integrated table later serving as a matrix for homeostatic regulation. Interrelated clusters of metabolic and haemodynamic parameters —effector complexes of compensatory demands — constitute the physiological segments of regulatory algorithms (RAs), the fundamental building blocks of homeostatic equilibrium regulation. These RAs are classified into systemic and targeted homeostatic regulators according to their impact on the inertial properties of the somatic continuum and their overall significance for the body's overall functioning. Beyond the mathematical and graphical objectivisation of established physiological facts, this work proposes constructive solutions for the regulation of the cardiac cycle, respiration, and the somatic continuum as a whole — solutions not found elsewhere in any literature. The homeostatic regulation matrix described herein is viewed as a fragment of an integrated regulatory system governing the somatophysiological continuum of the body as a whole.

Keywords: FS: fluid system, GS: gas system, RA: regulatory algorithm, N: norm, M: matrix, CI: confidence interval, CC: cardiac cycle, CMIP: mean integral pressure of the heart, HE: homeostatic equilibrium.

MATERIALS AND METHODS

We regard placental mammals as fluid biological systems (FS) that begin to function in a gaseous environment (GS) once they reach the intrapartum stage. The precarious homeostatic 'dynamic equilibrium' of the FS within the GS is maintained by the somatic, neural and psychophysiological subsystems of the entire body. During the intrapartum period, the intrauterine regulatory apparatus of the foetus (haemodynamics, metabolism, circadian rhythms, etc.) is supplemented and partially supplanted by regulatory algorithms (RAs) for: pulmonary respiration (gas exchange and the metabolic functions of the lungs); the radical reconfiguration of systemic metabolism and central haemodynamics; the expansion and synchronisation of circadian rhythms; the gravitational vector (following the immersion weightlessness of the amniotic fluid); and other factors — i.e., the complete autonomisation of FS functioning upon transition to the GS.

We posit that the foundational principle of biological body function is the phylogenetic and ontogenetic establishment, and subsequent maintenance, of systemic homeostatic/informational equilibrium (1, 2). Through sensory information channels of

extra-and interoception, the psyche constructs and sustains — dynamically adjusting as needed — a mirror-symmetric representation of the external environment. Both internal organs and the external world are external objects to the psyche. The polymorphic sensory field constitutes a line of mirror symmetry (informational equilibrium) between the external environment and the psyche.

We conducted studies of accessible metabolic and haemodynamic parameters and their interrelationships in the vascular systems of clinically healthy human subjects — defined as the 'norm', N. The metabolic and hemodynamic indicators obtained via catheterisation of afferent/efferent vessels, cardiac chambers, the pulmonary artery, the aorta, the sigmoid sinus, the right hepatic vein, and the kidney comprise pressure and metabolic levels measured directly from the organ itself. Using correlation and factor analysis, we constructed an integrated table of metabolic-haemodynamic interrelations, which we define as the 'homeostatic regulation matrix', M (3). The mathematically processed and grouped data presented in the M tables are interpreted as the external manifestation of the relationships among parameters within the examined segment of the somatophysiological continuum (metabolism and haemodynamics) of the FS, sustaining the current homeostatic equilibrium of the system as a whole.

Research into the mechanisms by which metabolism influences haemodynamics revealed stable constellations of blood biochemical parameters that uphold haemodynamic constancy. While parameter values remained within the 'norm zone' (CI), in pathology (compared with N), we observed a radical alteration — in terms of component composition, quantity, and sign of correlations — within the biochemical complexes that ensure systemic and regional haemodynamic stability (4, 5). In other words, haemodynamic stability under N and under pathological conditions is supported by various metabolic complexes and qualitative shifts in regulatory algorithms. We consider the stable clusters of interrelated metabolic and haemodynamic parameters presented in our reports to be segments of systemic regulatory algorithms responsible for maintaining overall homeostatic balance.

Beyond the autonomous automated cardiac cycle, the regulatory algorithms of homeostatic equilibrium are conceptualised as stable neurophysiological constructs — fixed chains of neural interactions that generate patterns of goal-directed behaviour upon the activation of a compensatory need. The phylogenetic/ontogenetic balance of such compensatory needs will be addressed separately. For the purposes of this work, a simplified scheme of need actualisation, incorporating a basic effector block (the RA), consists of the following stages:

1. afferent informational flow from a point/zone of significant (exceeding the CI) homeostatic imbalance/informational asymmetry;
2. actualisation of a compensatory need (dominant for the duration of its relevance) and its coded equivalent — the goal image;
3. initiation of the need's effector segment, the vectorial structure for goal attainment — the RA;
4. goal-directed behaviour, action;
5. interaction with the sought object/goal;

6. resolution of the parametric/informational homeostatic imbalance;
7. elimination of need/repression of homeostatic RA.

In other words, the RA is a neurophysiological informational dynamic structure of goal-directed action, an effector construct of an actualised need (6, 7).

The corpus of raw data we obtained allowed us to construct graphical and mathematical portraits of certain RAs across the range of somatic continuum parameters studied. The results of the structural and functional integration of haemodynamic parameters of afferent/efferent vessels and cardiac chambers are presented as comprehensively as possible, allowing us to produce detailed graphs of the structure and dynamics of the systemic RA and the cardiac cycle (8, 9, 10, 11). The design principles of homeostatic compensatory RAs are presented in Table M and linear graphs of the structure of certain RAs (3, 4, 5).

Systemic and targeted compensatory homeostatic RAs are differentiated according to their influence on the inertial properties of the somatic continuum and their hierarchical significance for the body's overall viability.

1. The cardiac cycle (CC), which emerges in the foetus at 5-6 weeks of pregnancy, is defined as an autonomous, automated systemic RA of the 1st hierarchical level, which does not have a compensatory genesis; rather, it serves as an imperative electrical, magnetic, resource-based, and impulse-wave informational regulator for all bodily systems from the intrapartum period onwards.

   The average duration of this RA is 0.8 seconds at rest, with the capacity for significant shortening (while preserving structure and function) depending on the workload. The inertial potential for the final degradation of the physiological continuum during cardiac arrest is 3-5 minutes. Cardiac arrest is a singular attractor for all regulatory systems and RAs in the body (12).

   Our graphical and computational data demonstrate the functional dynamics and interaction structure of all registered elements of the CC RA — afferent/efferent blood flows, cardiac chambers, the transit of blood 'boluses' along the tract: right atrium → right ventricle → lungs → left atrium → left ventricle → aorta — as well as their relationship with the ECG and the peripheral pulse wave throughout the CC. We established the principles governing the synchronisation of ventricular stroke volumes, pressor regulation of pulmonary artery and aortic valve dynamics, and related phenomena (5, 8, 9, 10, 11). Beyond substantiating known physiological facts, we propose constructive regulatory solutions for the CC that are not found elsewhere. We present some of them here.

   Analysis of intracardiac haemodynamic interrelations allowed us to conclude that, within the CC RA structure, a functional regulatory complex of a 'three-chamber ventricular block' operates during systole: 1) left ventricle — anterograde wave impulse and blood flow; 2) right ventricle — anterograde impulse and blood flow; 3) 'myocardium spongy chamber' —retrograde impulse and volumetric blood flow, with outflow directed via the coronary sinus and Thebesian veins into the atrial

block. Together, these flows constitute a single stroke volume (an integral information/resource package) during a single ventricular systole.

Synchronised with left ventricular systole, the retrograde pressor impulse and coronary sinus blood flow are directed toward the zone of integral (haemodynamic, gaseous, metabolic, hormonal, etc.) terminal convergence of systemic venous flows (3, 5, 13). The regulatory scope of the retrograde impulse at the coronary sinus will be the subject of a separate study.

The dynamics and vectors of the extra/intracardiac myocardial pressor effect throughout the cardiac cycle form an integral pressor structure of the "inner heart," which we term "cardiac mean integral pressure," CMIP (11, 14). We posit that CMIP regulates the sequence of CC phases, a universal central governor of the body's entire hydrodynamics.

Our data confirm the modulatory influence of CMIP upon the brain via wave-like structures within the haemodynamic pathway, which unite heart and brain into a single hydrodynamic framework with phase-varying volume, configuration, and variable pressor regulatory patterns (14).

The automated regulatory algorithm of the cardiac cycle is conceived as a functional dynamic structure shaped by an initial informational package: the electromagnetic impulse from the sinoatrial node pacemakers and the cascade of spiral myocardial biomechanical transformation.

2. From the onset of lung expansion in the intrapartum period, pulmonary respiration (a systemic-homeostatic RA) possesses a compensatory genesis. It sustains gas exchange, acting as the contact exchange zone between the FS and the external gaseous environment (O_2 uptake, CO_2 elimination).

The average duration of this gas-exchange RA is 3-5 seconds, with the potential for marked shortening under metabolic demand. The inertial potential for terminal decompensation of the physiological continuum upon deterioration of pulmonary respiration (biological death from anoxia) is up to 10 minutes.

By rhythmically altering intrathoracic pressure, pulmonary respiration influences central venous return haemodynamics, impacting caval blood flow, the magnitude of hydrodynamic resistance to outflow from the brain, the hepatic vein, the coronary sinus, and right atrial function. The metabolic scope of the lung encompasses sectors of protein, fat, and carbohydrate metabolism, as well as the regulation of biologically active substances (activation/inactivation of serotonin, norepinephrine, bradykinin, angiotensin, etc.).

Pulmonary respiration is the sole autonomic process that combines automatic regulation of function with the possibility of voluntary (including conscious) influence across the sympathetic/parasympathetic spectrum.

We consider conventional views on the mechanisms by which blood gases (pO_2 and pCO_2) and their arteriovenous gradients affect metabolic processes to be insufficient. To assess the regulatory mechanisms of gas homoeokinesis, we propose the following integral regulatory gas indices: 1) total plasma gas pressure, PS=(pO_2 +

pCO_2); 2) gas functional gradient: the difference in total arterial and venous gas pressures, DPS=(pO_2 + pCO_2) Ao - (pO_2 + pCO_2) V; 3) exchange gradient, DP=pO_2 - (pO_2 + pCO_2) V (15). We contend that the total gas pressure in the body's fluid media, derived from the total alveolar gas pressure, represents an evolutionarily determined foundation for the formation of all types of pressure, including haemodynamics. The total pressure complex (TPC) of gases constitutes an integral component of a unified cooperative system regulating organismal homeostasis based on pressure factors (arterial, venous, tissue, cerebrospinal fluid, oncoosmotic, etc.). The relative independence of the TPC from mobile O_2 transport factors (Hb, stroke and cardiac output, HbO_2 dissociation, etc.) allows it to be regarded as a stable, inertial gaseous homeostatic regulator.

3. A continuum of compensatory needs that shape the structures and interrelations of biochemical complexes within RAs for metabolic support of homeostatic equilibrium (HE). The average duration of these RAs varies widely, as does the inertial potential for terminal decompensation leading to irreversible homeostatic changes (hours/days). The RA groups identified through the processing of primary data form: complexes of intraorgan and systemic interrelations of metabolism and hemodynamics; the synergistic interaction of these complexes; and an integral matrix of organismal homeostasis regulation, etc. The qualitative metabolic-haemodynamic relationships presented in the Matrix table represent indices of interaction among the constructive elements and vectors that balance the somatophysiological homeostatic continuum of the body in a state of 'dynamic equilibrium'. In other words, in a stable, resource-compensated state during the study, the body maintains the current inertial homeostatic balance within the range of Type 3 regulatory algorithms (RAs) using internal resources. This means that adaptive oscillations of parameters occur within the "normal zone" (NZ). Table M reflects precisely this phase of the body's state: the regulatory interplay of metabolites and haemodynamics in a state of relative HE stability, in the absence of significant homeostatic imbalance or actualised vital compensatory needs.

   The interaction among the parameters in Table M is evidenced by the sign (+, 0, -) of the correlation coefficient, which allows for grouping complexes of mutual influence and interaction of indices, i.e., identifying the structure of integral regulatory algorithms that ensure the stability of a specific homeostatic parameter.

   We investigated the following blood biochemical parameters: electrolytes (K, Na) in plasma and erythrocytes; blood gases (O_2, CO_2, HbO_2); blood acid-base balance (pH, SB); blood proteins (Hb, P-n, F-n); as well as systolic, diastolic, pulse, and mean pressures of each organ, and the A, X, V, Y waves for the right atrium. Within the range of HE regulatory parameters we obtained, numerous active biochemical substances involved in metabolic sequences are absent, including minerals, hormones, glucose, nitrogen (which presumably plays a role in regulating gaseous homoeokinesis via pressure levels), etc. We believe that the Homeostatic Regulation Matrix described here, consisting of synergistic sets of intraorgan and systemic RAs, constitutes a fragment of the regulation of the integral somatophysiological continuum of the body.

CONCLUSION

The fundamental principle of biological organismal function, i.e., the maintenance of homeostatic equilibrium, is ensured by compensatory needs. A goal-directed compensatory need is triggered by the psyche upon a significant disruption of the homeostatic/informational equilibrium, i.e., when adaptive oscillations of the indicator persistently exceed the boundaries of the 'norm zone'.

The somatic/neurophysiological efferent elements constituting the compensatory needs structure are the basic homeostatic regulatory complexes: regulatory algorithms. The structure of a regulatory algorithm within the somatic segment of homeostatic regulation is a complex of interrelations between metabolic and hemodynamic parameters that serves to balance the parameter within the 'norm zone'.

The 'homeostatic regulation matrix' is a segment of the systemic regulator governing the body's somatophysiological continuum.

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