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From Law to Biological Norm: A Contemporary Perspective on The Histophysiology of Corporal Fluid Compartments

Kamilov Dzhamshid Yuldashevich
Assistant Professor Tashkent State Medical University
kamilovjamshid3@gmail.com
Olimzhonova Dilnura Bakhtiyor kizi
Student of Tashkent State Medical University
Utkurova E'zozakhon Dilmurodovna
Student of Tashkent State Medical University

Abstract.
This article examines the conceptual paradigms of such eminent scholars as Abu Ali ibn Sino (Avicenna) and Alikhantura Soghuni, whose fundamental contributions significantly influenced the evolution of global medicine and science. Furthermore, based on a comprehensive analysis of scientific literature, the paper elucidates contemporary scientific views on the essential properties and homeostatic functions of the internal milieu, specifically focusing on the histophysiology of interstitial fluid and blood.

Keywords: Blood, plasma, formed elements, erythrocytes, leukocytes, platelets, nutrients, oxygen.

Introduction

The only part of the body that has no blood vessels is the cornea of the eye. The cornea obtains oxygen directly from the air.

Abu Ali ibn Sina (Avicenna), an outstanding scholar from Central Asia, made a fundamental contribution to the development of global medical science. His magnum opus, “Kitab al-Qanun fi-t-Tibb“ published in Arabic in Rome in 1593 and subsequently translated into the major European languages, shaped the direction of global medicine for centuries[1].

Ibn Sina was one of the first to establish the significance of exogenous factors in the aetiology of diseases, postulating the possibility of pathogen transmission via water and air. His works contain detailed clinical and morphological descriptions of pneumonia, jaundice, measles and smallpox, whilst the surgical techniques he developed retain their educational value to this day.

As part of his humoral-anthropological theory, the scholar established a hierarchy of ‘heat’ and the functional significance of the organs. The heart was assigned a central place in this system as the source of vital energy (‘pneuma’). According to his views, although blood is synthesised in the liver (which he metaphorically likened to concentrated blood), it acquires its essential properties through its functional connection with the cardiovascular system. The work systematically describes the gradient of organ vitality: from the lungs and spleen to the kidneys and pulsating vessels (arteries). Particular emphasis in his writings is placed on the study of angiology, specifically the morphofunctional characteristics of the venous and arterial systems[2].

In Alikhanut Soguni’s seminal work “Shifo ul-Ilal”, an inseparable link is posited between spiritual development and an individual’s physical condition. The author emphasises the dualistic nature of knowledge: ‘Knowledge is divided into two key areas: theological and medical (the science of the body). Neglecting the principles of medicine leads to a loss of well-being and a deterioration in quality of life, whereas the pursuit of medical science is a fundamental human duty for the preservation of health[3].

Of particular scientific significance is the author's classification of constitutional types (temperaments), based on the dominance of certain biological fluids in the body:

1. Sanguine type (dominance of blood): Characterised by a hypersthenic physique, marked facial hyperaemia (a healthy glow) and emotional lability, with a predominance of cheerfulness and optimism. Morphologically and functionally, such individuals are distinguished by high physical resilience and determination[4].
2. Choleric type (dominance of bile): Clinically manifested by asthenia, a gaunt face and an icteric (yellowish-wheat) hue of the skin. A high rate of psychomotor reactions and increased metabolic activity ('rapid bile circulation') are noted.
3. Melancholic type (erroneously referred to in the text as 'business client', orig. 'savdo'): Described by a dark or sallow complexion, thinness and a tendency towards depressive states, anxiety and social isolation.
4. Phlegmatic type (dominance of phlegm/mucus): Morphologically characterised by a tendency towards abdominal obesity, tissue oedema and physical inactivity. The psycho-emotional profile is marked by inertia, drowsiness and emotional rigidity[5].

Blood pressure (BP) is a key indicator of the functional state of the cardiovascular system and of homeostasis in general. Sudden haemodynamic fluctuations (hypertension or hypotension) clinically manifest as decompensation, general weakness and asthenia. The muscular component plays a leading role in the regulation of systemic pressure: both the contractile activity of the myocardium and the tone of the smooth muscle cells of the vascular wall[6].

The heart, functioning as a central pump, ensures adequate tissue perfusion in accordance with the body's metabolic needs by altering the rate and force of cardiac contractions. According to epidemiological data, individuals who are overweight or obese have a significantly higher risk of developing hypertension compared to those with a normal body mass index (BMI). The clinical picture of pathologically elevated blood pressure is characterised by cephalgic syndrome, vertigo, tinnitus and, in some cases, haemorrhagic manifestations (nosebleeds). A historical analysis of the works of the great physicians of the past confirms their profound intuitive understanding of these physiological principles[7].

In modern biomedical terms, the body's internal environment (blood, lymph, interstitial fluid) is regarded as a single functional complex of fluid connective tissues responsible for trophic, protective and homeostatic functions. Blood, consisting of plasma (the liquid phase) and formed elements (red blood cells, white blood cells, platelets), performs vital tasks in the transport of nutrients and gases (oxygen and carbon dioxide), ensuring the immune response and thermoregulation.

Blood is a specialised tissue of the internal environment (of mesenchymal origin) that plays an integrative role in ensuring metabolic exchange between organs and systems. Morphologically, it is characterised as a liquid intercellular substance (plasma) containing suspended formed elements that perform transport, protective and regulatory functions[8].

Interstitial (tissue) fluid constitutes the immediate microenvironment of cells, filling the intercellular spaces. Formed by the ultrafiltration of blood plasma through the capillary walls, it acts as a mediator of transcapillary exchange, delivering nutrients and oxygen to the cells and accumulating metabolic waste products. Interstitial fluid consists of water, electrolytes, amino acids, hormones and metabolites, which determine the chemical homeostasis of the tissue microenvironment.

The lymphatic system performs a drainage function, returning excess interstitial fluid to the bloodstream, which is a critically important mechanism for preventing the development of oedema. Lymphatic capillaries originate in the connective tissue as blind-ended (closed) vessels, possessing high permeability to macromolecules and cellular elements. Lymph formation ensures not only fluid balance but also the implementation of immune control by transporting antigens to regional lymph nodes. Thus, the dynamic equilibrium within the 'blood–interstitium–lymph' system is a fundamental prerequisite for maintaining the homeostasis of the body's internal environment[8].

Fluid balance disorders: Excessive accumulation of interstitial fluid, exceeding the physiological norm, is identified as oedema (localised or generalised). Normally, tissue fluid is drained via lymphatic capillaries, where it is transformed into lymph and undergoes biological filtration in regional lymph nodes. An imbalance in the volume of this fluid (hyperhydration or dehydration) inevitably leads to critical disturbances in systemic metabolism.

Morphofunctional parameters of blood: Blood accounts for 7–8% of total human body weight (on average 4.5–6.0 litres). It constitutes a heterogeneous system comprising:

- Plasma (55–60%): an aqueous solution (90–92%) containing protein fractions (albumins, globulins, fibrinogen), electrolytes and nutrients.
- Formed elements (40–45%):
- ✓ Red blood cells: provide respiratory function due to their haemoglobin content.
- ✓ White blood cells: provide immune defence (including phagocytosis and antibody production).
- ✓ Platelets: key agents of the haemostatic system, initiating coagulation processes.

Integrative functions of the tissues of the internal environment: The tissues of the internal environment (of mesenchymal origin) are characterised by their isolation from the external environment and body cavities, being situated within the body's internal compartment. Common morphological features of these tissues include high regenerative capacity and plasticity, which determine their adaptive potential.

The key functions of this system include:

1. Trophic: maintaining cellular nutritional homeostasis.
2. Respiratory: transporting gases between the respiratory surface and tissues.
3. Protective: participation in humoral and cellular immunity.
4. Skeletal-mechanical: formation of the structural framework of organs.

The degree of expression of the above functions varies depending on the histological specialization of a specific tissue type, ensuring the dynamic constancy of the body's internal environment[9].

Blood is a specialized tissue of the internal environment (of mesenchymal origin), consisting of a liquid intercellular substance (plasma) and formed elements suspended within it. The total blood volume in an adult ranges from 4.0 to 7.0 L (on average 5.0–5.5 L), which accounts for 7.0–7.5% of total body weight. The relative density of blood is 1.050–1.060 g/cm³, and the pH of arterial blood is maintained within a strict homeostatic range of 7.36–7.44. The volume fraction of formed elements in the total blood volume is defined as the hematocrit[10].

The liquid phase of blood—plasma—has the following composition: water (90–92%), organic compounds (7–9%), and minerals (~1%). The plasma protein fraction (approximately 6–8%) is classified into three functional groups:

1. Hemostatic system proteins: These maintain a dynamic equilibrium between coagulation and fibrinolysis. The key procoagulant is fibrinogen, synthesized in hepatocytes. During the cascade of coagulation reactions, under the influence of thrombin, soluble fibrinogen is transformed into an insoluble polymer—fibrin—which forms the basis of the clot and prevents critical blood loss. Ca2+ ions, vitamin K, platelet factors, and stabilizing factor (factor XIII)[11].
2. Anticoagulant and fibrinolytic systems: Prevent intravascular thrombus formation. One of the most important natural anticoagulants is antithrombin III, which inhibits serine proteases of the coagulation system.

Proteins of the immune response and the acute phase of inflammation: This group includes immunoglobulins (antibodies), complement system proteins, and α-macroglobulins. The complement system is an effector component of the innate immune system that initiates the lysis of foreign cells and the development of an inflammatory response. α-macroglobulins function as universal antiproteases, blocking the activity of exogenous and endogenous proteases, and also act as transporters of cytokines and growth factors, limiting tissue damage during inflammation.

The transport pool of plasma proteins consists of a heterogeneous group of proteins that facilitate the selective and non-selective transport of metabolites. Key representatives include: albumins, apolipoproteins, transferrin, haptoglobin, ceruloplasmin, transcortin, and others.

Research Methodology

In this study, комплекс analytical methods were applied to investigate the histophysiological characteristics of the body's internal fluid environment. During the research process, comparative analysis of theoretical sources, generalization of statistical data, and systematic evaluation of physiological indicators were used. In particular, scientific indicators such as total blood volume accounting for approximately 7–8% of body weight (4.5–6.0 liters), plasma proportion of 55–60%, and formed elements comprising 40–45% were analyzed. Additionally, physiological norms were compared based on erythrocyte counts of $4.0–5.2\times10^{12}$/L in men and $3.9–4.9\times10^{12}$/L in women, as well as leukocyte levels ranging from $3.8–9.8\times10^{9}$/L. The study employed a systematic approach, analysis and synthesis, statistical comparison, and interpretation of scientific sources to scientifically explain the functional relationship between blood, interstitial fluid, and lymph.

Results and Discussion

The most abundant fraction consists of albumins (molecular weight approximately 65–70 kDa), synthesized in hepatocytes. In addition to maintaining plasma oncotic pressure, they perform vital storage and transport functions: they transport hydrophobic compounds (free fatty acids) and steroid hormones, and also transport unconjugated bilirubin to the liver for subsequent detoxification and excretion.

Morphological Classification of Blood Cells Blood cells are specialized structures derived from the red bone marrow that function within the circulatory system. Traditionally, they are divided into three main populations:

1. Erythrocytes (red blood cells): Highly specialized anucleate structures (in mammals) whose primary function is to facilitate respiratory gas exchange by transporting oxygen and carbon dioxide.
2. Leukocytes (white blood cells): A group of fully developed nucleated cells that mediate various aspects of innate and adaptive immunity (phagocytosis, antibody production, cytotoxicity).
3. Platelets (blood platelets): Nucleus-free fragments of megakaryocyte cytoplasm that play an initiating role in the primary and secondary mechanisms of hemostasis.

Red blood cells (erythrocytes) are highly specialized, nucleated, post-cellular structures shaped like a biconcave disc (discocyte). This morphology, first described by A. Leeuwenhoek in 1673, provides the maximum surface-to-volume ratio, which optimizes gas exchange processes[12].

Morphometric and quantitative parameters:

- Average diameter: 7.5 μm; surface area of a single erythrocyte — approximately 125 μm^2.
- Total surface area: the total area of the erythrocyte membrane in the body reaches 3,200–3,800 m^2.
- Reference values: for men—$4.0–5.2 \times 10^{12}$/L, for women—$3.9–4.9 \times 10^{12}$/L.

Gender differences are due to the stimulating effect of androgens on erythropoiesis. Red blood cell levels are characterized by physiological variability depending on age, climatic conditions (high-altitude hypoxia), and individual physiological status.

Cytological characteristics and chemical composition:

Unlike those of other vertebrates, mammalian red blood cells lose their nucleus and organelles during maturation, retaining only elements of the cytoskeleton, which ensure high plasticity as they pass through the capillaries of the microcirculatory bed. Dry matter accounts for 40% of the red blood cell's mass, 95% of which is hemoglobin—a complex iron-containing chromoprotein[13].

Functional role of hemoglobin and gas transport cycles:

Hemoglobin (Hb) forms reversible complexes with gases:

1. Oxyhemoglobin (HbO_2): formed upon binding with O_2 in the lungs for subsequent delivery to tissues.
2. Carbaminohemoglobin ($HbCO_2$): a compound with carbon dioxide, ensuring its transport from tissues to the respiratory surface of the lungs.
3. Carboxyhemoglobin (HbCO): a pathological, extremely stable compound with carbon monoxide (CO), which blocks the blood's respiratory function and leads to severe hypoxia.

In addition to their gas-carrying function, red blood cells play a key role in maintaining acid-base balance (the hemoglobin buffer system) and participate in the regulation of homeostasis through specific membrane receptors that bind biologically active substances and toxins[14].

Red Blood Cell Kinetics: The average lifespan of mature red blood cells in the systemic circulation is approximately 110–120 days (with physiological variations: up to 126 days in men and about 90 days in women, which is related to hormonal background and metabolic activity). The elimination of aging and defective forms (erythrocytosis) is carried out by macrophages in the spleen ("erythrocyte graveyard"), liver, and bone marrow.

Leukocytes (white blood cells): These constitute a heterogeneous group of nucleated cells that provide the effector mechanisms of innate and adaptive immunity. The reference range for leukocyte count in peripheral blood is 3.8–9.8 × 10^9/L. Leukocytes are capable of active amoeboid movement (diapedesis) through the capillary walls into tissues, which is achieved through the reorganization of the actin-myosin complex of the cytoskeleton[15].

Based on morphological criteria (the presence of specific granules), white blood cells are divided into two groups:

1. Granulocytes (granular white blood cells)

They are characterized by the presence of specific granules in the cytoplasm and a segmented nucleus (polymorphonuclear cells).

- Neutrophilic granulocytes (neutrophils): The most numerous population (50–70%). They have a diameter of about 12 μm. The nucleus of a mature segmented neutrophil consists of 3–5 segments connected by chromatin bridges.
  - Life cycle: They differentiate in the red bone marrow, circulate in the bloodstream for 8–12 hours, and then migrate into tissues. Total lifespan—up to 8 days. They are phagocytosed by macrophages.
  - Enzymatic apparatus: Primary (azurophilic) granules contain myeloperoxidase (2–4% of dry cell weight), which catalyzes the formation of highly toxic hypochlorous acid (HOCl), as well as cathepsins, elastase, and lysozyme. Secondary granules contain lactoferrin, collagenase, and alkaline phosphatase.
- Eosinophils: Participate in antiparasitic immunity and the regulation of allergic reactions.
- Basophils: Initiate immediate-type inflammatory reactions.

2. Agranulocytes (non-granular leukocytes)

This group includes lymphocytes and monocytes, which are characterized by the absence of specific granules and a non-segmented nucleus. They mediate specific immune responses (cellular and humoral) and provide phagocytic defense.

Platelets (blood platelets): These are nucleated fragments of cytoplasm that bud off from megakaryocytes in the red bone marrow. Their key role is to ensure primary (vascular-platelet) hemostasis: upon adhesion to damaged endothelium, they initiate a cascade of coagulation reactions, forming a primary platelet plug.

- Morphometric characteristics: They are the smallest among formed elements (2–4 μm) and lack a nucleus.
- Life cycle: Their functional lifespan in the systemic circulation is 5–11 days, after which they are eliminated by splenic macrophages.

Hematological profile: Whole blood is morphologically divided into plasma (55–60%)—a complex biochemical solution of nutrients, salts, and proteins—and formed elements (40–45%). Quantitative and qualitative abnormalities in these parameters (cytopenia or leukocytosis) are verifiable markers of pathological processes such as anemia, systemic inflammation, or hematopoietic neoplasms.

Lymphatic System and Interstitial Drainage: A dynamic equilibrium between blood plasma and interstitial fluid is maintained by the continuous reabsorption of excess tissue exudate into the lymphatic system. Lymphatic capillaries, located in loose fibrous connective tissue, arise blind and provide unidirectional transport of fluid into the venous system.

Lymph nodes—peripheral organs of the immune system that perform a barrier and filtration function—are located along the lymphatic pathways. As lymph flows through them, it becomes enriched with mature immunocompetent cells (lymphocytes and monocytes). The most significant clusters of lymph nodes (regional collectors) are located in the popliteal, inguinal, elbow, axillary, and cervical regions, as well as in visceral spaces (bronchopulmonary nodes). The lymphoid system also includes the spleen, which performs the functions of immune control of the blood and erythrocyte destruction.

Conclusion

An analysis of contemporary views on the histophysiology of the body's fluid systems confirms the fundamental continuity of scientific thought. The conceptual views of the great physicians of the past, such as Abu Ali ibn Sina and Alikhanutura Soguni , laid the theoretical foundation that has been fully confirmed by modern morphological science.

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