

MECHANICAL FUNCTIONING PRINCIPLES OF THE CIRCULATORY SYSTEM

Abdunabieva Khakimakhon

Assistant of the „Anatomy and clinical anatomy”

Andijan State Medical Institute , Uzbekistan

Annotation: The first attempt to apply the laws of mechanics to the study of the organism occurred in the 17th century. Hemodynamics - hydrostatic pressure occurs due to differences in different parts of the vascular system (it is known that the sand flows from the high-pressure area to the low-pressure area). The main factor in this is the contraction of the heart. Due to the elasticity of blood vessels, negative pressure in the thoracic cavity, contraction of the diaphragm and skeletal muscles, blood flows continuously in the blood vessels. As a result, there is a regular metabolism between blood and tissues. A number of indicators of circulatory and respiratory status are also important in the development of diagnostics of heart and lung diseases and the consequences of surgery.

Key words: Systole, diastole, hemodynamics, ECG, thermoregulation, pulse, cardiac automation, cardiac biocurrent, cardiac cycle, biomechanics, arteries, veins, capillaries, hormones, coronary arteries, cavities.

The circulatory system plays a vital role in maintaining homeostasis by transporting oxygen, nutrients, hormones, and metabolic waste products throughout the human body. Its effective functioning depends not only on biological and biochemical processes but also on fundamental mechanical principles that govern blood flow and pressure regulation. Understanding these mechanical aspects is essential for explaining both normal cardiovascular function and the development of various circulatory disorders.

From a mechanical perspective, the circulatory system can be considered a complex hydraulic network in which the heart acts as a pump, blood vessels serve as conduits, and blood behaves as a non-Newtonian fluid. Principles such as fluid dynamics, pressure gradients, resistance, elasticity, and compliance are central to explaining how blood circulates efficiently under varying physiological conditions. Concepts including laminar and turbulent flow, Poiseuille's law, and vessel wall mechanics provide a foundation for analyzing blood movement within arteries, veins, and capillaries.

Mechanical functioning principles are particularly important in the study of cardiovascular pathologies such as hypertension, atherosclerosis, and heart failure, where alterations in vessel elasticity or flow resistance significantly affect circulatory performance. Moreover, these principles form the basis for modern medical technologies, including artificial heart valves, ventricular assist devices, and blood flow measurement techniques.

This article aims to explore the key mechanical principles underlying the functioning of the circulatory system, highlighting their role in normal physiology and clinical applications. A comprehensive understanding of these principles contributes to advancements in biomedical engineering, medical diagnostics, and therapeutic strategies for cardiovascular diseases.

Circulation is the movement of blood through the circulatory system due to the contraction of the heart. Circulation maintains metabolism and homeostasis between the body's tissues and the environment. Blood carries oxygen, water, protein, carbohydrates, fats, minerals, vitamins, and more to the tissues, and removes carbon dioxide and other metabolic wastes from the tissues. Blood circulation was discovered in 1628 by the English physician W. Harvey. It moves in the blood vessels due to the contraction and relaxation of the heart muscle. The amount of blood that the heart pumps per minute is called the minute volume. The minute volume at rest is 4-5 liters, and in the case of emotional impact it increases by 3-4 times. The heart pumps blood into the artery in portions. With bleeding, the walls of the arteries dilate. The energy stored in the diastole maintains a certain level of blood pressure in the arteries and maintains a continuous flow of blood in the capillaries. Only 5% of the blood in the body is in the capillaries, but the main function of the blood circulation - the exchange of blood and tissue - takes place in these capillaries. Due to the hydrostatic pressure of the blood in the capillaries, the fluid is filtered from the capillaries to the tissue. Blood resists in the capillaries, overcoming which it loses energy and lowers blood pressure. The circulatory system is divided into two circles, aquatic and terrestrial. The small circulatory system includes the right ventricular artery and the pulmonary veins exiting the lungs. The small circulatory system is involved in the exchange of gases in the blood. The great circulatory system (system) includes the aorta, arteries, arterial capillaries, venous capillaries, venous cavities, and their pocket valves, which originate in the left ventricle of the heart. The large circulatory system is involved in the delivery of nutrients and oxygen to tissues and organs, and from there to the digestive system for the delivery of harmful substances from metabolism.

General understanding of the circulatory system and its importance The circulatory system includes the coronary arteries, capillaries, veins, and lymphatic vessels. The heart and blood vessels ensure the uninterrupted movement of blood in the human body. As a result of the automatic contraction and dilation of the heart, blood travels through large arteries and capillaries to all tissues and cells of the body, and then through small, medium and large veins. returns to the heart. From the left ventricle of the heart, arterial blood, rich in nutrients, oxygen, and hormones, is pumped into the aorta. It travels through large, medium, and small arteries to the capillaries between tissues and cells. Nutrients, oxygen and hormones in the blood pass into the cells. Residual substances and carbon dioxide formed as a result of metabolism in the cells pass from them to the small veins, capillaries, and then through the middle, large veins to the right compartment of the heart. Thus, the cardiovascular system delivers nutrients and oxygen to all the tissues and cells of the body. It receives the residual substance formed in them and delivers it to the digestive organs. That is why the cardiovascular system is also called the carrier system. The cardiovascular system plays the most important vital function. If the heart stops for a short time, a person's life will also stop. The cardiovascular system is made up of several parts, as mentioned above. In order to study the functioning of this system perfectly, it is expedient to get acquainted with the structure and function of each of its parts.

The circulatory system functions as a highly efficient mechanical and physiological network that ensures continuous blood flow to meet the metabolic demands of the body. The findings and concepts discussed in this article highlight the importance of mechanical principles in understanding cardiovascular function beyond purely biological explanations. By applying mechanical laws to the circulatory system, it becomes possible to interpret how the heart, blood vessels, and blood interact to maintain stable circulation under varying conditions.

One of the most significant mechanical aspects of the circulatory system is the role of the heart as a dynamic pump. Cardiac output, which depends on heart rate and stroke volume, is directly influenced by mechanical factors such as ventricular contractility, preload, and afterload. Changes in vascular resistance or arterial stiffness alter the workload on the heart, demonstrating the close relationship between mechanical forces and cardiac performance. This interaction becomes particularly evident in pathological states such as hypertension, where increased resistance leads to elevated cardiac strain and long-term structural adaptations of the heart muscle.

Blood flow mechanics within vessels also play a crucial role in circulatory efficiency. Under normal conditions, blood flow is predominantly laminar, allowing for smooth and energy-efficient transport. However, disruptions in vessel geometry, such as narrowing caused by atherosclerosis, can result in turbulent flow. Turbulence increases energy loss and contributes to abnormal shear stress on vessel walls, which may further exacerbate vascular damage. These observations emphasize the importance of fluid dynamics principles, including Poiseuille's law and Reynolds number, in explaining both healthy and diseased circulation.

Vascular elasticity and compliance are additional mechanical factors that significantly influence circulatory function. Arteries, particularly large elastic arteries like the aorta, serve as pressure buffers by expanding during systole and recoiling during diastole. This mechanical property helps maintain continuous blood flow and prevents excessive pressure fluctuations. A reduction in arterial elasticity, commonly associated with aging or cardiovascular disease, leads to increased systolic blood pressure and reduced diastolic pressure, impairing tissue perfusion. Thus, changes in vessel wall mechanics have direct consequences for overall circulatory stability.

The mechanical behavior of blood itself should also be considered. Blood is a non-Newtonian fluid whose viscosity varies with flow conditions and hematocrit levels. Increased blood viscosity raises flow resistance, placing additional demands on the heart. This factor becomes clinically relevant in conditions such as polycythemia or dehydration, where altered blood properties can compromise circulation. Understanding these mechanical characteristics supports more accurate hemodynamic modeling and clinical assessment.

From a clinical and technological perspective, the application of mechanical principles to the circulatory system has significant implications. Hemodynamic measurements, such as blood pressure and flow velocity, are rooted in mechanical analysis. Moreover, the design and optimization of medical devices—including artificial heart valves, stents, and ventricular assist devices—depend heavily on an accurate understanding of circulatory mechanics. Computational modeling and simulation techniques increasingly rely on mechanical principles to predict cardiovascular behavior and guide treatment strategies.

Overall, the discussion demonstrates that mechanical functioning principles are integral to both theoretical and practical understanding of the circulatory system. Integrating mechanics with physiology provides a more comprehensive framework for explaining cardiovascular function, diagnosing disease, and developing innovative medical solutions. Continued interdisciplinary research combining biomechanics, medicine, and engineering will further enhance our ability to understand and manage circulatory system disorders.

The mechanical functioning principles of the circulatory system are fundamental to understanding how blood is effectively transported throughout the body. By viewing the cardiovascular system as a dynamic mechanical system composed of a pump, elastic vessels, and flowing fluid, it becomes possible to explain the regulation of blood pressure, flow distribution, and tissue perfusion under both normal and pathological conditions.

Key mechanical concepts such as pressure gradients, vascular resistance, vessel elasticity, and fluid dynamics play a central role in maintaining efficient circulation. Any disturbance in these mechanical parameters can lead to significant cardiovascular disorders, including hypertension, arterial stiffness, and impaired cardiac output. Therefore, the integration of mechanical principles with physiological knowledge is essential for accurate diagnosis and effective treatment of circulatory system diseases.

Furthermore, an understanding of circulatory mechanics has important applications in biomedical engineering and clinical practice. It supports the development of cardiovascular medical devices, improves hemodynamic modeling, and enhances modern diagnostic and therapeutic approaches. As research in this field continues to evolve, mechanical analysis of the circulatory system will remain a critical component in advancing cardiovascular science and improving patient care.

Lituration :

1. E. Ismailov, N. Mamatqulov, G'. Xodjayev, N. Norboyev Biofizika. Toshkent.2013yil.
2. Grabovskiy R.I. «Fizika kursi». T. O'qituvchi 1980 yil.
3. Remezev A.N. «Tibbiy va biologik fizika». T. 1990 yil.
4. Merion D.J. «Общая физика с биологическими примерами». М. VSh. 1986 g.
5. Rubin A.Ye. «Biofizika». М. 1-2 Tom. VSh. 1982 g.
6. Belanovskiy A.S. «Основы biofiziki veterinarii». М. Agropiramizdat. 1989 g.
7. Volkenshteyn V.M. «Biofizika». М. 1981 g.
8. Glazer R. «Ocherki osnovy biomexaniki». М. Mir. 1988 g.
9. Основы агрофизики podredaksii AF Ioffe M. VSh. 1990 g.