# METHOD OF CALCULATING GLOBAL BLOOD FLOW IN THE HUMAN BODY USING HETEROGENEOUS CALCULATION MODEL

**Sharipov Daler Kuchkarovich**
(TATU Scientific adviser)

**Soliyeva Dilfuza Tulkin kizi**
(TATU master)

## ABSTRACT

In the articleas a basis for the global blood flow model (that is, a closed model describing the blood circulation in general) it is proposed to use a quasi-dimensional nonlinear model of the pulsating flow of a viscous incompressible fluid through an elastic tube.

**Key words:** blood flow model, calculation models, calculation methods. mathematical model, numerical algorithm.

## INTRODUCTION

The mechanics of blood flow have been the focus of many researchers for quite some time. The first works in this field belong to Euler and later Jung, who in 1808 mathematically analyzed the wave nature of blood flow in arteries and calculated the speed of the pulse wave [1]. However, the first realistic model describing pulsatile blood flow and arterial pressure appeared much later [2]; he used the linear Navier-Stokes equation and treated the vessel as a uniform rigid tube. Modern methods of studying pulsatile blood flow are very complex and diverse.

**STATEMENT OF THE PROBLEM**

As the main mathematical model of blood flow, it is proposed to use a quasi-dimensional non-stationary model of incompressible fluid flow through a tube with thin, elastic walls.

$$\partial S_k / \partial t + \partial (u_k S_k) / \partial x = \varphi_k (t, x, S_k, u_k, r_i)$$

$$\partial u_k / \partial t + \partial (u_k^2 / 2 + p_k / \rho_k) / \partial x = \psi_k (t, x, S_k, u_k, r_i)$$

where t is time; x-coordinate along the length of the vein calculated from the point of conjugation with the veins of young generations;

S-blood density (in this work, it was assumed to be equal to 1g/cm 3);

k- vessel number

p- section of the vessel

PS- average linear flow velocity along the section

t- pressure in the vessel, calculated from the atmosphere;

UK- a term describing the flow or flow of blood, which can be used, for example, for modeling blood loss in damage to the vessel walls, blood transfusion, etc.;

- a term describing the change of momentum under the influence of external forces (gravity, friction, etc.);

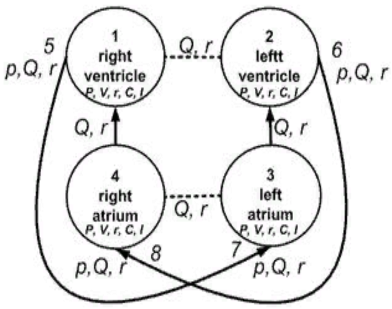
A set of parameters describing -i.

OE effect on k-tube. The elastic properties of the vessel walls can be called the "equation of state", which determines the dependence of the cross section of the vessel on the pressure in this part:

$$p_k - p_{*k} = \rho c_k^2 f_k (S_k)$$

Real blood flow in the area of bifurcation of blood vessels has a very complex structure.

Individual chambers may have additional connecting channels (and ventricular defects) (Fig. 1).



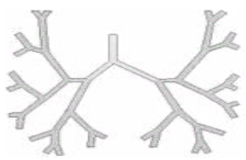

**Picture. 1. Diagram of the four-chamber model of the heart, taking into account the defects of the interchambers**

First of all, it is necessary to highlight some difficulties that arise in the practical application of the considered models, because they are characterized by many parameters that determine their structural and physical-mechanical properties.

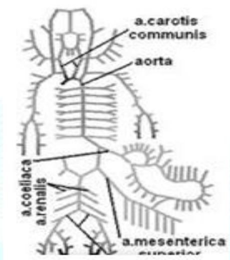
Determination of parameters was carried out by comparing experimental data and the results of test calculation experiments that consider the functioning of the circulatory system under normal conditions.

The methodology of the preliminary calculations, as well as the obtained results, are described in detail. Development of numerical methods used for calculation, as well as analysis and

**Blood flow in large and small arteries**



**Picture. 2. Propagation of pressure waves through the arteries of pulmonary circulation**



**Picture. 3. Propagation of pressure waves along the arteries of a large circle of blood circulation**

**Summary**

Computational results using dynamic models of blood flow in large vessels and heart presented in this work showed the possibility of their practical application. Naturally, some tasks may require a detailed description of the structure of the blood vessel graph, as well as a more accurate selection of parameters. However, these difficulties do not pose major limitations and can be easily overcome when appropriate experimental data are available.

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