MATHEMATICAL MODELING OF TRANSMITRAL HEMODYNAMICS

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Introduction. Mitral valve prolapse (MMD) refers to the manifestation of connective tissue dysplasia of the heart (DCTS). the problem of DCTS syndrome, the most common manifestation of which is MMD, attracts close attention of researchers for a number of reasons. Timely diagnosis of PCB and assessment of clinical significance of this pathology is an actual problem for patients with cardiological profile.

The study of intracardiac hemodynamics at various degrees of this pathology is of great practical and theoretical importance. Mathematical models of normal mitral valve hemodynamics are known in the literature.

Aim. Theoretically substantiate the use of mathematical modeling in transmitral hemodynamics.

Materials and methods. In the work comparison of clinical and physiological data with the results of mathematical modeling was carried out. The volume of the left and right ventricles was determined. The type of hemodynamics, impact volume, ejection fraction, LV myocardium thickness were also estimated.

The presented mathematical model describes transmitral hemodynamics taking into account valve pathology.

Results and discussion. Dynamics of myocardial polarization. Reduced myocardial function is accompanied by depolarization of myocytes, where the number of active N cells is a periodic function of time. In a conductive system, the depolarization rate is proportional to the number of unexcited M cells:

$$\frac{dN}{dt} = \frac{ln10}{t_d}M$$

Having denoted the relative number of depolarized cells n=$\frac{N}{N+M}$, t – from the beginning of the depolarization, T, T_d и T_r=T-T_d, duration of the cardiac cycle and to integrate the equations, we obtain the dependence of the relative number of depolarized cells on time in the form:

$$n(t)=\begin{cases} 1 - c_1 * 10^{\frac{T}{Td}} \\ c_2 * 10^{\frac{1-Td}{Tr}} \end{cases}$$

where constants are determined from the conditions of continuity and periodicity. The following describes the dynamics of myocardial contraction using the Hill equation, which establishes a relationship between muscle stress P and the rate of contraction V. To establish a relationship between myocardial stress and cardiac pressure, we will consider a radius sphere surrounded by a wall of h-thick muscle fibers, developing muscle stress P at each point, and the passive Pierre stress associated with elasticity in the direction of the fibers. Having denoted the ratio of its hole area per q , and taking into account that the hydrodynamic resistance is inversely proportional to the square of the hole area, we will present the formula as follows:

$$q_m(p_{1v}, p_{1a}) = \begin{matrix} \frac{p_{1a-P_{1v}}}{Rm} \\ q^2\frac{p_{2a-P_{1v}}}{Rm} \end{matrix}$$

Conclusions. 1. Mathematical model of transmitral hemodynamics at mitral valve prolapse is developed taking into account different degree of regulation.

2.The model allows to determine the dynamics of contractile function of the left heart, hemodynamics parameters, including the shock volume, ejection function, pressure fluctuations and blood flow rate.

3. The proposed mathematical model allows to give a physical treatment to intracardiac processes and to estimate efficiency of management of patients with PCB.