ARCHITECTONICS OF THE LEFT VENTRICLE OF THE HEART
AND SPECIFIC FEATURES OF BLOOD FLOW CAUSED
BY POSTINFARCTION CARDIAC ANEURYSM

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Studies of architectonics of the left ventricle (LV) of the heart and the structure of blood flow through the LV in patients with ischemic disease of the heart (IDH) are necessary for optimizing the methods of radical correction of various postinfarction complications [1].

Pathological changes in the geometry and internal architectonics of the LV of the heart caused by a postinfarction aneurysm were studied in this work. Changes in blood flow structure induced by the aneurysm affect intraventricular and systemic hemodynamics and cause a sharp increase in the intraventricular pressure. Presumably, such a sharp change in the integral characteristics of hemodynamics is partially due to destruction of the mechanism of blood flow swirling inside the LV.

It was shown in the preceding works [2, 3] based on theoretical and experimental data that the blood flow inside the LV of the heart is swirled. Swirling is caused by the major cusp of the mitral valve providing tangential conveyance of blood into the LV, helical arrangement of trabeculae on the inner surface of the LV (Fig. 1a), papillary muscles (PM) serving as a guide for expulsion of blood into the aorta (Fig. 2a), heart rotation during systole, and Segner's arrangement of aorta and pulmonary artery. All these factors form the mechanism of blood flow swirling.

Visual studies of the blood flow structure inside the LV were carried out on laboratory animals using the X-ray method and special X-ray contrast particles. Also, X-ray photographs of contracting LV were analyzed. It was found that the major cusp of the mitral valve provides a tangential conveyance of the blood into the LV, so that the blood flow near the LV walls is swirled by the helical trabeculae on the inner surface of the LV. The swirling continues when the mitral and aortic valves are closed. During systole, blood inside the LV circulates around the PM, which involves the core of the flow into swirling. On opening the aortic valve, the relative position of the PM is changed and the blood flow is guided into the aorta. Thus, the blood flow inside the LV of the heart is swirled throughout the entire cardiac cycle (Fig. 1b).

To provide blood flow swirling, the heart combines the functions of centrifugal and volumetric pumps. Centrifugal pumps provide dynamic head, which depends on the liquid flow rate, whereas volumetric pumps provide static head. Static head virtually does not depend on the liquid flow rate inside the pump, and the energy of liquid is transmitted as the energy of pressure.

According to Euler's equation, swirling of a flow induces an increase in the ventricular ejection and prevents development of congestion zones in the LV cavity. Rotational motion of blood inside the LV continues during the period of isotonic contraction, when the mitral and aortic valves are closed. Therefore, at the beginning of systole the ventricle has to change the direction of blood motion instead of driving a stationary mass of blood to move. Rotating mass of blood exerts an additional pressure on the walls of the ventricle, which causes permanent passive tension of the myocardium. According to Starling's law, this can increase the systole efficiency [4].

It is obvious that a decrease in the ventricular ejection is caused to a certain extent by changes in the flow structure and internal architectonics of the LV. The most common types of LV aneurysms were considered from this point of view.

1. Aneurysm of the ventricular septum makes the middle segment and apex of the heart protrude into the cavity of the right ventricle of the heart. The boundaries of the aneurysm can be either distinct or indistinct. In the former case, the aneurysm can be regarded as an additional chamber inside the LV cavity. Papillary muscles are completely transformed, flattened, and thinned, which disturbs the blood flow structure. Formation of a stable nonmigratory vortex in the additional chamber of-
Fig. 1. Internal structure and blood flow pattern inside the LV of the heart: a) helical arrangement of trabeculae on the inner surface of the LV; b) X-ray photographs of blood flow inside the LV.

Fig. 2. Papillary muscles and trabeculae of the LV: a) normal; b) modified by aneurysm.

ten results in thrombosis of its cavity. If the boundaries of the aneurysm are indistinct, transformation of papillary muscles and trabeculae is less pronounced. Therefore, the danger of thrombosis is reduced.

2. Aneurysm of the anterior septum and apex of the heart transforms the structure of the apical segment. Sclerosis of the anterior PM results in thinning, flattening, and accretion of the anterior PM to the free wall. The posterior PM remains undistorted (Fig. 2b). As a sequence, relative position of the PM is changed and they cease to serve as a guide in forming swirling flow of blood. Immobilization of one of the muscles causes circulation of blood inside the cavity around the undamaged PM (Fig. 3b) instead of normal swirling helical flow (Fig. 3a).