Pathomorphology of Variant Relationships between Left Ventricle and Interventricular Septum in Hypertensive Heart

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We carried out complex pathomorphological analysis of hearts (n=640) with pronounced left ventricular hypertrophy accompanied by asymmetric hypertrophy of interventricular septum, which were isolated from patients died of hypertension. The most frequent variants of pathomorphological interrelationships between the left ventricle and interventricular septum in hypertensive hearts were septoconcentric, posteroseptal, and anteroseptal relations. The study revealed alterations in the left ventricle (the state of ventricular cavity, its volume, and structural remodeling) characteristic of each variants and underlying the pathognomonic manifestations in cardio- and hemodynamics. The role of coronary and myocardial factors in the development and progression of myocardial hypertrophy was established.

Key Words: *hypertensive heart; myocardial hypertrophy; coronarography; cardioventriculography; morphometry*

The hypertensive heart (HH) is characterized by a pronounced left ventricular hypertrophy, which is a hallmark of long-term hyperfunction of the heart in essential hypertension. The development of cardiac hyperfunction includes certain stages: short-term (compensatory), long-term (adaptive), and final (decompensation) stages [2,8].

The study of peculiarities of the left ventricular hypertrophy in HH revealed some individual pathological forms. Of them, the most frequent and important is disproportional or asymmetric hypertrophy of the interventricular septum in HH [10]. This kind of hypertrophy is characterized by extremely clear-cut functional, hemodynamic, and pathomorphological manifestations and dramatically affects the basic factors of patho- and thanatogenesis, as well as the character of heart insufficiency [7].

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Our aim was to examine the incidence and pathomorphology of alternative relationships between the left ventricle and interventricular septum in HH and to elucidate the role of myocardial and vascular (coronary) factor in the development of myocardial hypertrophy.

MATERIALS AND METHODS

We examined 800 HH and documented asymmetrical hypertrophy of interventricular septum of various severity in 426 men and 214 women (80% cases) aging 58.8±0.4 years. Every fifth case in the experimental group was matched with a control case of the same sex and age. The control group comprised 128 hearts from persons died of casual reasons without clinical and pathomorphological manifestations of HH.

In all control and experimental cases, the state of coronary system was examined using the method of polypositional postmortem contrast coronarography. In addition, we used combined WHO

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coronarography method [4] to calculate the mean area of atherosclerotic damages to three major coronary arteries (the right, anterior interventricular, and circumflex branch of the left coronary artery). The state of the ventricles and interventricular septum in HH was studied using original method of postmortem contrast coronarography [4].

For morphometry, endomyocardial specimens were isolated from HH (n=100) and cleared preparations were made. To this end, the sections were dehydrated in alcohols of increasing concentrations and then treated with salicylic acid methyl ether. The thickness of the muscle fibers in the myocardium and interventricular septum of HH was measured using an ocular grid and the quantitative morphometric methods [9]. The diameter of muscle fibers in subepicardial, intramural, and subendocardial layers of HH was measured [1]. Based on the data of volume-mass and planimetric cardiometry [3], we determined the hypertrophy expansion index as a ratio of the thickness of the interventricular septum to that of the left ventricular wall [12]. The obtained values were distributed in variants and compared with normalized (mean comparable) value of 1.6 [14]. The data were processed statistically using Student's t test and alternative variations.

RESULTS

Serial sections of polypositional cardioventriculography revealed alterations in HH cavities and pronounced ventriculoseptal myocardial hypertrophy. Hypertrophy of the interventricular septum was disproportional and asymmetrical, and its topographic and anatomical relationships with hypertrophy of the left ventricle were characterized by alternative directivity. The septoconcentric variant of HH was observed most frequently (n=340 or 53.1%). Significant hypertrophy of the septum observed predominantly in its proximal segments was accompanied by dramatic hypertrophy of the left ventricular walls of HH with clear concentric directivity. This feature resulted in the development of a peculiar shape of the left ventricle with narrowed and elongated cavity. Such ventriculoseptal relationships remodel the HH cavities in a specific way yielding their common elongated shape with a peculiar ventricular bulging (Fig. 1).

The septoconcentric version of HH was confirmed by morphometric data and hypertrophy expansion index (Table 1). This index (1.60±0.02) significantly differed from the control value of 0.90± 0.01 and corresponded to the mean comparable value of 1.6 [13,14]. In septoconcentric HH, the cardiac index decreased to normal, while high blood pressure was maintained due to enhanced total peripheral vascular resistance [11]. Hypertrophy of left ventricle not accompanied by dilation enhances its absolute tension, but does not promote the increase in cardiac index, although it prevents the decrease of this index because of increased afterload. During persistent development of the dilation, this mechanism cannot maintain the cardiac index at the normal level [6]. It is noteworthy that the ejection fraction and the mean rate of shortening of the circular myocardial fibers significantly and persistently increased. Therefore, potentiation of contractile function of the left ventricle can be explained not by accelerated shortening of the muscle fibers, but by it specific character in this variant of HH.

The second in incidence was septum-posterior wall variant of HH (n=180, 28.1%) determined by combined disproportional hypertrophy of the interventricular septum and posterior ventricular wall. In these cases, hypertrophy was most pronounced in the distal segment of the septum, while hypertrophy of the posterior left ventricular wall spread to the apex of HH. The cavity of the left ventricle resembled a funnel; its volume decreased radically. In this pathological variant, the volume of the left ventricle could attain $^1/_3$ right ventricular volume, which assumed an ellipsoid shape (Fig. 2).

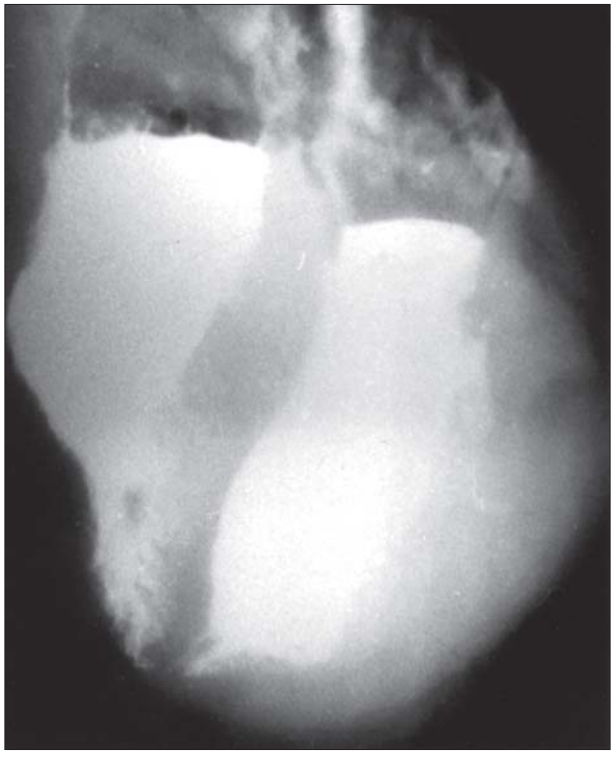

Fig. 1. Cardioventriculogram of patient I, 58 years. Septoconcentric variant of HH.

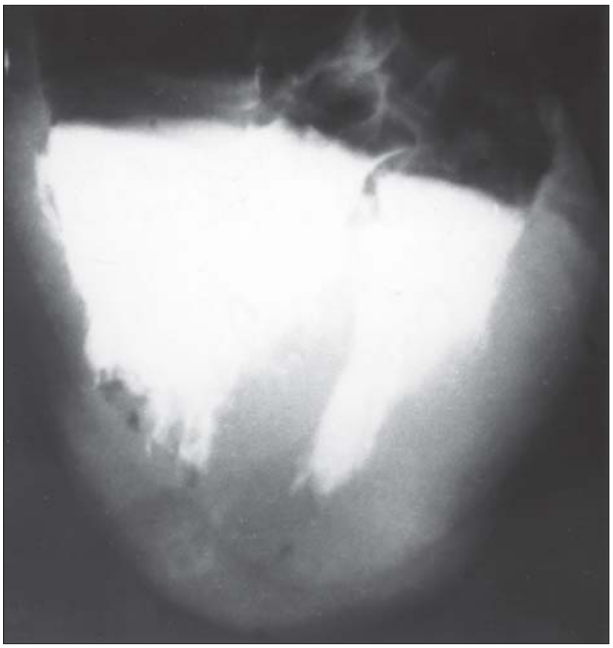

Fig. 2. Cardioventriculogram of patient G, 60 years. Posteroseptal variant of HH.

The septum-posterior wall variant of HH affected hypertrophy expansion indices (Table 1). The mean experimental data (1.40±0.02) surpassed the control (0.90±0.02) and approximated the mean comparable index. There was a direct functional correlation between the degree of elimination remodeling of the left ventricle and severity of its diastolic dysfunction. It is known that mobility of severely hypertrophic posterior wall of the left ventricle is strictly limited, which promotes the development of intraventricular pressure gradient and sporadic obstruction of its outlet orifice. There is no correlation between variations of blood return to the left ventricle and degree of hypertrophy of its posterior wall and septum in HH [15].

Septum-anterior wall variant of HH (n=120, 18.8%) characterized by pronounced combined disproportional hypertrophy of the interventricular septum and anterior left ventricular wall was least incident. In these cases, the hypertrophic asymmetry of the septum was most pronounced in its distal and apical segments, while hypertrophy of the left ventricular anterior wall was most frequently observed in the basal proximal region. During elimination, the cavity of the left ventricle assumed a triangle shape, whose volume in most cases attained to a half volume of the right ventricle in HH characterized by typical spheroid shape (Fig. 3).

The septum-anterior wall variant of HH also affected hypertrophy expansion index (Table 1). The mean index in the experimental group (1.30±0.01) surpassed the control value (0.80±0.03) and approximated to the mean control value. There was a functional interrelation between the character of mitral valve movements, on the one hand, and the degree of septum-anterior wall hypertrophy and shrinkage of left ventricular cavity, on the other hand. The movement pattern of the anterior cusp of the mitral valve was pathologically distorted, which resulted in the development of regurgitation flow of various intensity. In addition, the left ventricular end-diastolic pressure was elevated, which reflected disturbances in diastolic relaxation of HH leading to manifestations of basic symptoms of the disease [2,5].

Analysis of the genesis of concomitant ventriculoseptal hypertrophy in different variants of HH revealed the characteristic relations between the area of atherosclerotic lesion in basic coronary arteries and thickness of myocardial muscle fibers (Table 2). The mean area of atherosclerotic lesions in HH patients varied from 49% (in males) to 56.6% (in females), while the mean value for entire group of patients was 52.8±2.6%. These averaged data surpassed the control value of 40.4±1.2% by 1.4 times.

The mean thickness of muscle fibers in left ventricular myocardium and interventricular septum was 13.9±0.2 μ in females and 14.80±0.16 μ in males, the total averaged value in HH patients being 14.40±0.18 μ. The thickest fibers were obser-

TABLE 1. The Relation of Thickness of Interventricular Septum and Left Ventricular Walls to Hypertrophy Expansion Index in Different Variants of HH (M±m)

Hypertrophy variant and examination area		Thickness, mm	Hypertrophy expansion index	
			control	experiment
Septoconcentric	septum	3.60±0.04	0.90±0.01	1.60±0.02
	concentric wall	2.20±0.02		
Septum-posterior wall	septum	3.30±0.02	0.90±0.02	1.40±0.02
	posterior wall	2.40±0.02		
Septum-anterior wall	septum	3.10±0.01	0.80±0.03	1.30±0.01
	anterior wall	2.30±0.01		

ved in HH men, while similar value in women was 1.1-fold smaller. The mean fiber thickness for the total group (14.40±0.19 μ) approximated the corresponding value in men with HH and significantly differed from the control (11.90±0.19 μ).

To obtain a reliable pathomorphological criteria of hypertrophic heart, we carried out morphometry of muscle fiber diameter in basic myocardial layers. The mean values (Table 3) show that the thickest fibers were found in the intramural layer of HH myocardium. This dominating location of thick myocardial fibers was characteristic of men (16.2, 18.2, and 17.6 μ) and women (15.8, 16.4, and 16.6 μ). In men, this parameter was maximum in the intramural layer in left ventricular posterior wall (18.2 μ). In women, the fiber thickness attained maximum (16.6 μ) in the intramural layer of the interventricular septum of HH.

The second in value of muscle fiber diameter were the fibers in subepicardial layer of the myocardium in all examined areas of HH. Finally, the minimal values of this parameter were found in the subendocardial layer of the myocardium. These observations revealed a strong positive correlation between the severity of atherosclerotic lesions in major coronary arteries and the morphometric indices of myocardial hypertrophy, *i.e.* thickness and diameter of muscle fibers (Tables 2 and 3). Similar correlations were revealed in sex-age distribution of the died HH patients and in comparison with the type-matched controls.

The results of quantitative morphometric analysis suggest that the character of myocardial hypertrophy can vary during its development. On the one hand, it can be coronary in nature caused by pronounced and extensive coronary atherosclerosis associated with chronic myocardial hypoxia, and on the other hand, it can result from hyperfunction caused by the compensatory response of myocardium to the hemodynamic shifts produced by the major disease. The reported morphometric criteria of myocardial hyperfunction indicate decreased load per unit mass of HH or diminished systolic tension. Therefore, myocardial hypertrophy can compensate to a certain degree the inferiority of muscle tissue in HH and elevated load in this tissue. However, this compensation can be insufficient, because the growth of HH weight is paralleled by exhaustion of adrenergic control, which leads to dramatic drop in the contraction force and pronounced disturbances in relaxation of left ventricle [7,8].

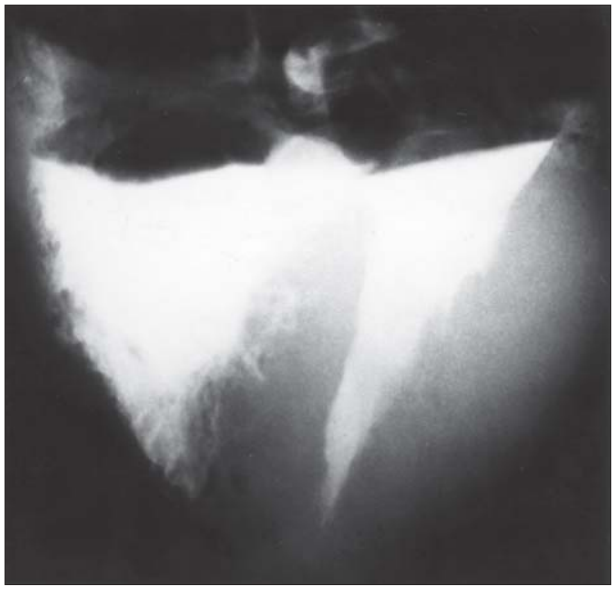

Fig. 3. Cardioventriculogram of patient A, 62 years. Anteroseptal variant of HH.

Thus, the revealed and substantiated interrelations between the left ventricle and interventricular septum in HH attest to the existence of septoconcentric, septum-posterior wall, and septum-anterior wall pathological variants. In each of these variants, the alterations of asymmetric hypertrophy of inter-

TABLE 2. Area of Atherosclerotic Damage of Major Coronary Arteries (μ^2) and Thickness Myocardial Muscle Fibers (μ) in Left Ventricle and Interventricular Septum in HH Patients of Both Sex (*M*±*m*)

Index	Sex		Total
	men	women	
Number of observations	50	50	100
Mean area of atherosclerotic lesions in three major coronary arteries			
control	32.0	48.8	40.4±1.2
HH	49.0	56.6	52.8±2.6
Mean thickness of muscle fibers in left ventricle and interventricular septum			
control	11.60±0.24	12.20±0.13	11.90±0.19
HH	14.80±0.16	13.9±0.2	14.40±0.18

TABLE 3. Diameter of Muscle Fibers of Basic Myocardial Layers in Left Ventricular Wall and Interventricular Septum in HH Patients of Both Sex (μ, *M*±*m*)

Myocardial regions and layers		Control		HH	
		men	women	male	female
Anterior wall	subepicardial	11.8	11.4	14.4	14.8
	intramural	12.2	12.0	16.2	15.8
	subendocardial	11.0	10.6	13.6	13.2
Posterior wall	subepicardial	11.3	11.9	15.2	14.8
	intramural	13.6	14.0	18.2	16.4
	subendocardial	12.2	11.1	15.0	14.5
Interventricular septum					
	subepicardial	12.0	10.8	15.2	14.7
	intramural	13.1	12.2	17.6	16.6
	subendocardial	11.7	11.0	14.8	13.9

ventricular septum, the state of the left ventricle and its cavity as well as individual remodeling of ventricular structure are reliably pathognomonic. In addition to etiopathogenetic reasons, the decisive role in the development of hypertrophy in HH is played by the vascular (coronary) and myocardial factors.

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