Pathomorphological Variants of Midventricular Obstruction of Interventricular Septum during Hypertrophic Cardiomyopathy

V. D. Rozenberg and L. M. Nepomnyashchikh

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Postmortem contrast cardiac ventriculography, coronarography, volume-mass and planimetric cardiometry, as well as echocardiography and pathomorphological data correlation technique were employed for examination of the hearts from patients died from hypertrophy cardiomyopathy (n=100). The following variants of midventricular hypertrophy of the interventricular septum (midventricular obstruction) were established: midleft ventricular, midright ventricular, midproximal, midmaximal. Isolated distal apex hypertrophy and apical hypertrophy were also documented. These variants and forms of cardiac pathology are determined by peculiar changes in geometrical structure of the septum and left ventricle. Multiplanar variability and mobility of interventricular septum combined with peculiar catenary shape promote specific abnormalities of intracardiac hemodynamics determining dissociation between the echocardiographic and pathomorphological diagnostic data and underlying the leading elements of patho- and thanatogenesis of hypertrophic cardiomyopathy.

Key Words: *hypertrophic cardiomyopathy; midventricular hypertrophy of interventricular septum; cardioventriculography; planimetric cardiometry; pathomorphology*

Hypertrophic cardiomyopathy (HCMP) belongs to hard-diagnosed diseases triggered by primary damages to the heart. Etiology of this disease is far from being understood. Genetic factors play the key role in the development of HCMP. Idiopathic (primary) HCMP is inherited according to autosomal dominant type with high penetration and characterized by genetic heterogeneity. Nonspecific myocarditis, closed injury of the heart [5], immunological aberrations [14,15] and other etiological factors play an important role in the development of secondary HCMP.

Isolated and pronounced hypertrophy of interventricular septum (IVS) is a leading pathomorphological manifestation of HCMP. Localization and geometry (asymmetry) of IVS hypertrophy greatly vary. First of all, IVS hypertrophy of different origin reduces and sometimes even eliminates the left ventricular cavity, which determines hemodynamic features and related criteria of clinical and paraclinical differential diagnostics. These criteria can be determined by modern ultrasonic diagnostic techniques. However, there is no close positive correlation between the echocardiographic and pathomorphological data in HCMP patients [2,11]. At the same time, extremely complicated structure and geometrical variability of IVS during HCMP are the corner stones underlying changes in intracardiac hemodynamics and thanatogenesis.

Our aim was to reveal the pathomorphological criteria to evaluate and diagnosticate the importance of IVS alterations during HCMP.

MATERIALS AND METHODS

The examined organs were the hearts of the patients (n=100), who died from HCMP (76 men and 24 wo-

Department of General Pathology and Pathomorphology, Institute of Regional Pathology and Pathomorphology, Siberian Division of the Russian Academy of Medical Sciences, Novosibirsk. ***Address for correspondence:*** pathol@cyber.ma.nsc.ru. Nepomnyashchikh L. M.

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men, mean age 44.6±0.8 years). The mean duration of the disease was 10.2±0.4 years. The control hearts (n=100) were taken postmortem from age- and sex-matched individuals died from accidents, who had no clinico-pathomorphological manifestations of HCMP or other noncoronary myocardial diseases. Another reference group (control II) comprised hearts of individuals died from essential hypertension (38 men and 12 women, mean age 44.2±0.2 years).

The state of IVS and cardiac cavities were examined by the method of postmortem contrast polypositional cardioventriculography [4], which is equivalent to intravital method of angiocardiography. For complete and clear visualization of IVS, the left anterior skew projection was serially used in positions comparable to the control. Cardioventriculography data on alterations of IVS during HCMP were compared with intravital echocardiography data obtained within 1 month before the fatal outcome. Significance of this analysis was attained by the use of volume-mass and planimetric cardiometry, which calculated external (equatorial) and internal (depth) diameter of cardiac cavities [2]. To exclude the coronary factor, the complex analysis took into consideration the data of postmortem contrast coronarography and targeted histotopographic examination of IVS [2]. The data were processed statistically using Student's t test and alternative variations.

RESULTS

Comparable cardioventriculography revealed different types of asymmetric hypertrophy of IVS and the corresponding characteristic changes in the left ventricle during HCMP. In 64% cases we found basic variants of midventricular hypertrophy of IVS determining midventricular obstruction, an individual form of obstructive HCMP [12]. In this group, middle-interventricular variant was seen most frequently (in 22 cases, 34.4%). It was characterized by pronounced midventricular hypertrophy of IVS and left ventricular walls combined with marked reduction of the cavity and volume of the left ventricle. At the same time, the volume of the right ventricle preserved, while the left one assumed a typical funnel-like shape with pronounced decrease in the depth diameter in all segments (Fig. 1, *a*).

Midright ventricular variant ranked second (18 cases, 28.1%) among all cases of midventricular obstruction. It was characterized by clear-cut median hypertrophy of IVS and left ventricular walls with insignificant decrease in its cavity and volume. Pronounced median hypertrophy of IVS, which was thicker than the wall of the left ventricle and slightly turned the proximal segment of IVS, contributed to shrinkage of the right ventricular cavity. The right ventricle assumed a typical triangular shape with markedly decreased volume (Fig. 1, *b*). In this variant of midventricular obstruction, the volume of the right ventricle 2-6-fold surpassed that of the left ventricle.

Midproximal variant of midventricular obstruction was observed in 14 cases (21.9%; Fig. 1, *c*). However, despite essential changes in the form of IVS combined with pronounced modification of the internal structure of cardiac cavities, the exterior appearance of the heart and its equatorial diameter remained virtually unchanged.

The most rare form of midventricular obstruction was mid-maximal variant (10 cases, 15.6%). This variant was characterized by highly pronounced hypertrophy of IVS. Reduction of the cavity in the left ventricle was extremely pronounced and its volume became 2-4 lower than that of the right ventricle. The proximal segment of IVS assumed a queer hook-like shape and performed a so-called obstructive turn (Fig. 1, *d*).

Distal apex hypertrophy of IVS was observed in 26% cases. It was characterized by pronounced hypertrophy of the walls of the left ventricle and, in particular, of its apical aspect juxtaposed with hypertrophied distal segment of IVS. This type of IVS hypertrophy was characterized by reduction of the left ventricular cavity, its volume 2-3-fold surpassed that of the right ventricle (Fig. 2). In 10 cases (10%) we observed extremely pronounced isolated hypertrophy of the apical aspect of the heart (apical HCMP). The apex of the heart and the apical segment of IVS formed an "apical" structure replacing free cavity in both ventricles (predominantly, in the left one, Fig. 3). This kind of hypertrophy decreased the inner (depth) diameter of the ventricles, external dimensions of the heart increased insignificantly. The weight of the hearts with apical hypertrophy of IVS and apical HCMP (532.2±12.2 g) was greater than in the control (310.2±14.2 g) and reference (412.6±14.4) groups. Correlation analysis of echocardiographic and pathomorphological data made it possible to characterize sensitivity, specificity, and differentially-diagnostic significance of echocardiographic assessment of IVS status during HCMP. In all variants of midventricular obstruction, complete correlation of the data obtained by different methods was documented only in 28 cases (43.7%). The echocardiographic diagnostic criteria were partially confirmed by pathomorphological examination in 20 cases (31.3%), while in the rest 16 cases (25.0%) these criteria proved to be erroneous and were not corroborated by the pathomorphological data. In patients with distal apex hypertrophy of IVS or apical form of HCMP, the correspondence between echocardiographic and pathomorphological data was complete, partial, or null in 10 (27.8%), 18 (50%), and 8 (22.2%) cases, respectively.

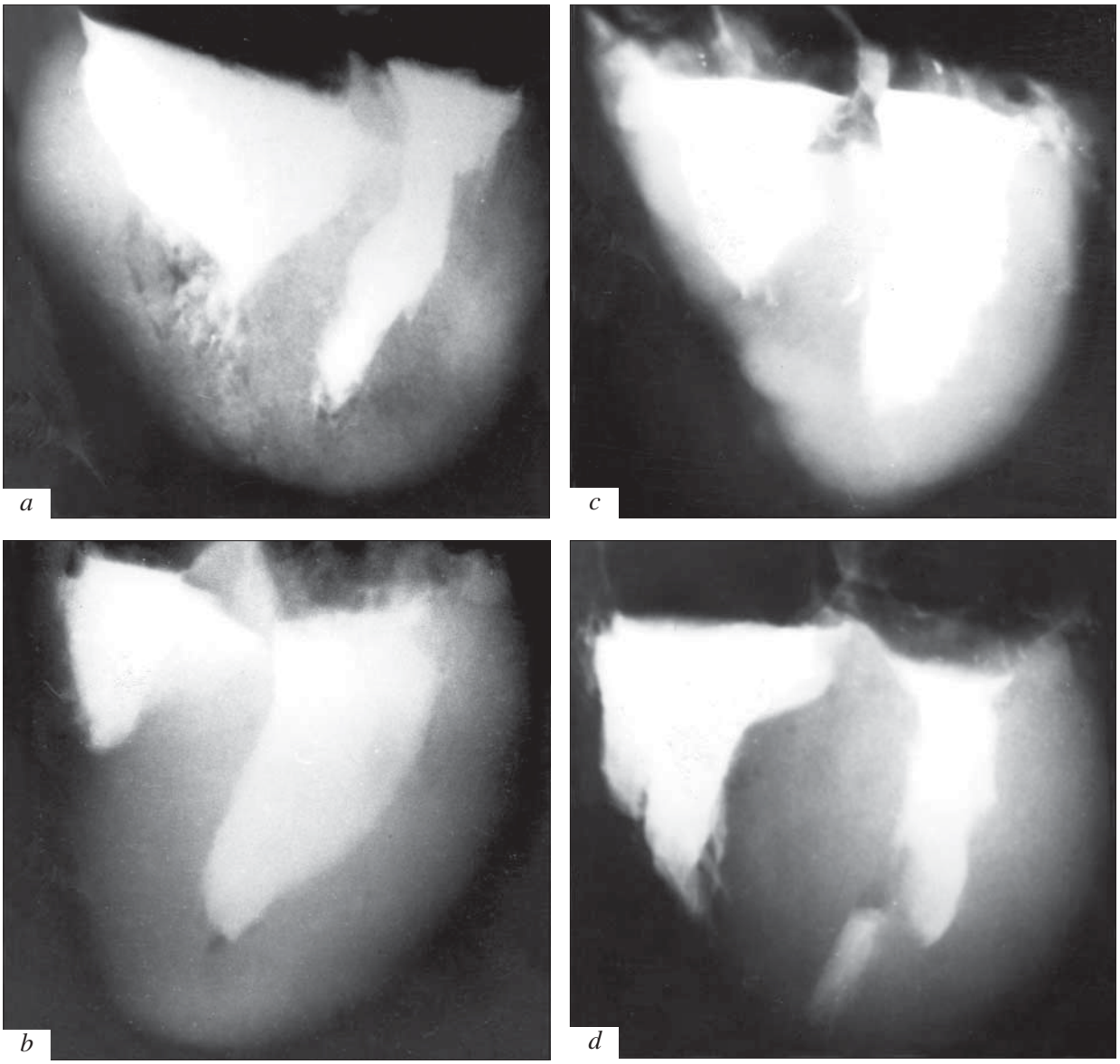

Fig. 1. Variants of midventricular hypertrophy (obstruction) of interventricular septum (IVS) during hypertrophic cardiomyopathy. Postmortem contrast cardioventriculography. *a*) midleft ventricular variant with pronounced midventricular hypertrophy of IVS and left ventricular wall accompanied by marked shrinkage of deformed ventricular cavity and preserved volume of the right ventricle, patient V., 40 years; *b*) midright ventricular variant with marked midventricular hypertrophy of IVS, which surpassed the thickness of the left ventricular wall and decreased free cavity of the right ventricle, patient K., 46 years; *c*) midproximal variant with asymmetric hypertrophy of IVS and its turn at valve rings, which curved long-shaped left ventricle, patient A., 44 years; *d*) midmaximal variant with pronounced hypertrophy of IVS; thickness of IVS 2-fold surpassed thickness of the left ventricular wall, while volume of the left ventricle was 2-fold lower than that of the right ventricle, patient G. (48 years). Here and in Figs. 2 and 3: 3-fold demagnification from original x-ray films.

Complex pathological analysis revealed complicated geometrical structure of IVS in patients with HCMP, which corresponded to its specific structure developed during the life with this pathology: concavity in transversal projection and convexity in the sagittal plane [8]. The weight of IVS during various forms and variants of HCMP (142.3±3.0 g) was 2.6-fold greater than in the control group (52.9±2.3 g). No correlation between the weight of IVS and pathological structures in this region of the heart was reveled. The prevalence of patients with midventricular obstructions as individual form of obstructive HCMP and complicated alterations in geometry of IVS and left ventricle corroborate possible existence of two mechanisms in the development of pressure gradient [6]. It is noteworthy that pronounced hypertrophy and altered structure of IVS eliminated the cavity of the left ventricle and drastically decreased its volume in all specified variants of midventricular hypertrophy. These alterations were pathognomonic and positively corre-

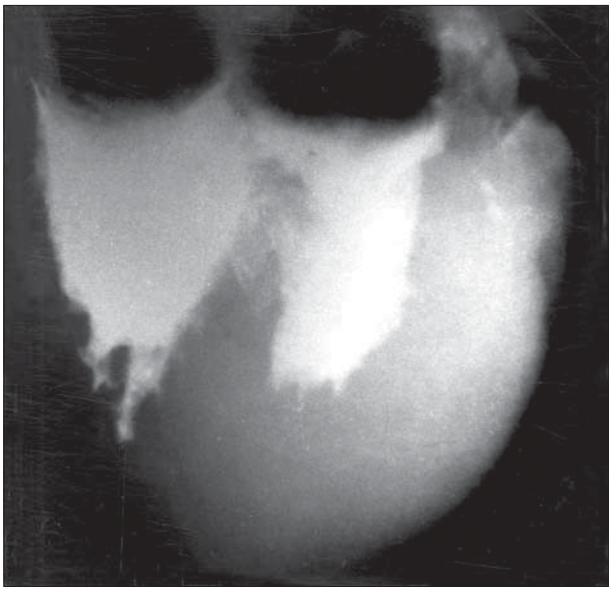

Fig. 2. Distal apex hypertrophy of IVS with pronounced hypertrophy of left ventricular walls and, in particular, the apical aspect of the ventricle associated with hypertrophied distal segment of IVS in patient N. (42 years). Postmortem contrast cardioventriculography.

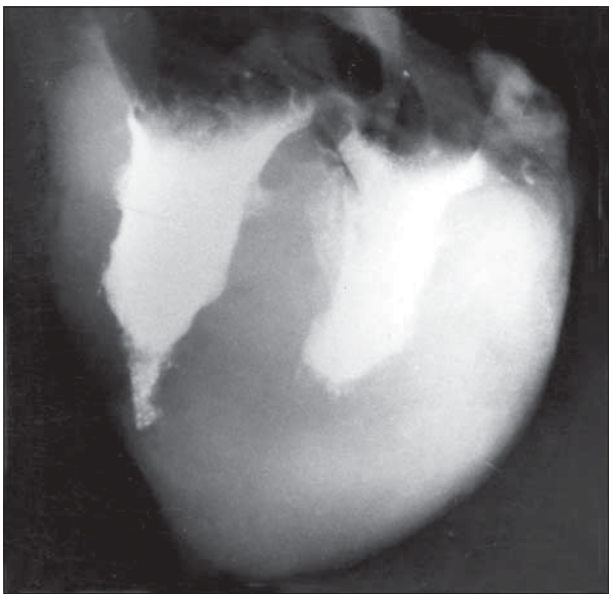

Fig. 3. Apical form of hypertrophic cardiomyopathy with pronounced hypertrophy of apical segment of IVS and the walls of left ventricle, which form a common apical structure reducing the cavity of both ventricles, the effect is more pronounced in the left ventricle. Patient B. (46 years).

lated with the echocardiographic data, thereby confirming authors' skepticism on clinical significance and the incidence of obstruction of the left ventricular outlet during HCMP [9]. During distal apex IVS hypertrophy and apical form of HCMP, the distal and apical segments of IVS form a common functional structure with the apex of the heart, thereby greatly decreasing the amplitude of IVS motions and eliminating systolic increase of its width [7].

Thus, the changes of IVS during HCMP are determined by peculiarities of its structure related to the form and variant of the disease, while asymmetry of hypertrophic manifestations underlies the character of the pathology (predominantly, in the left ventricle). While revealing the essence of echocardiographic and pathomorphological diagnostic dissociations, it is prerequisite to take into consideration variability of normal IVS, the differences in the geometry of its left and right ventricular muscle layers, and also the differences between the shape of static (postmortem) IVS and its intravital geometry in the unloaded heart [2,3]. The leading role in insignificance of the relevant echocardiographic data is played by peculiar catenaryal construction of IVS, whose motion can shift the mitral valve thereby inducing paradoxical systolic approach of its anterior cusp to IVS [13]. Within certain limits, the catenaryal structure of IVS determines its hypokinesia and asymmetric hypertrophy, and favors selective recording of the segments situated in the location area during 2D-scanning.

It should be noted that variability in different planes and motility of IVS [1] radically modify intracardiac hemodynamics, which leads to differential diagnostic peculiarities in each form and variant of established HCMP. At the initial stages of the developing disease, the changes in IVS reflect implementation of adaptive mechanisms. However, the progressive alterations in IVS during HCMP significantly affect the volume of ventricular cavities, promote the development of obstructive syndrome, modify the pressure gradient, and affect the status of the valve (atrioventricular) rings and other anatomic structures in the heart [10]. At the same time, while assuming the structure characteristic to each form and variant of the pathology, IVS becomes the victim of the disturbances of intracardiac hemodynamic. Thus, a peculiar vicious circle is produced, which incorporates itself into the total pathogenic chain of cardiac decompensation events developing during HCMP.

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