Pathomorphology of Myocardial Bridges and Their Role in the Pathogenesis of Coronary Disease

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The hearts of patients who died of coronary disease and had myocardial bridges were studied by postmortem coronary angiography, cardioventriculography, and complex pathomorphological analysis. The relationship between the incidence and pathomorphology of myocardial bridges, on the one hand, and the type of blood supply, segmentary topography of the major coronary arteries, geometry of the left ventricle, and coronary changes in different forms of coronary disease, on the other, was analyzed. Diagnostic criteria were developed and the main components of the etiology, patho- and thanatogenesis in coronary patients with coronary arteries not affected by atherosclerosis are presented.

Key Words: *coronary disease; myocardial bridges; pathomorphology; diagnostic criteria*

Cases of coronary disease, when changes in coronary arteries (CA) detected by selective vital and postmortem coronary angiography do not correspond to pronounced clinical picture of the disease, attract much recent attention of clinicians and pathomorphologists. Atherosclerotic changes in CA in these cases are minor and not complicated or even absent. The data [9] persuasively indicate that in about 27% coronary patients coronary atherosclerosis is not the only etiological factor of the disease. It was demonstrated that the important role in some forms of coronary disease is played by myocardial bridges (MB).

Life-time recognition of MB became possible since the end of the 1960s after introduction of selective coronary angiography into clinical practice [6]. MB are muscle bundles (muscular loops or arches) crossing CA on the front and causing its strictures during systole. We speak about MB when a branch of CA situated in the subepicardial fatty tissue passes partially intramurally [8]. According to published data, MB on the left CA occur in 42% and on the right artery in 15% cases. MB cause compression of the vascular wall during exercise, which leads to pronounced myocardial ischemia. In these cases (in the absence of atherosclerotic changes in CA) MB can be responsible for anginal attack, myocardial infarction, and sudden death [11]. MB can be diagnosed by selective coronary angiography detecting focal "diving" of CA with "saw wave" phenomenon, reflecting systolic compression of the vessel at the site of crossing with MB [2]. CA is narrowed by more than 75% during the systole and completely restored during the diastole [6]. Despite the interest to MB and their possible role in the development of myocardial ischemia, these structures remain little studied.

We analyzed the incidence of MB in relation to peculiarities of CA and coronary system in general and studied the etiological and pathogenetic role of MB in coronary disease.

MATERIALS AND METHODS

Hearts of 400 patients dead from different forms of coronary disease were examined. MB were detected in 144 (36%) cases; 96 of these were men, 48 women, the mean age was 42.2±0.2 years. Complex pathomorphological studies were carried out in all cases.

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The reference group included 256 patients dead from coronary disease with manifest atherosclerotic stenosis of CA. Control group consisted of 60 age-matched subjects who died of accidental causes (forensic medical autopsies) without MB and coronary disease according to pathomorphological analysis.

In the main group CA status was studied by polypositional contrast coronary angiography in our modification in all cases; the method was used alone and in combination with standard anatomical methods recommended by WHO [4,5]. Three main CA branches (right, anterior interventricular, and circumflex) were studied on coronarograms of opened and spread hearts. Each branch was divided into 4 segments equal by the intima area, estimated by the standard WHO anatomical method.

Coronary system of the hearts was studied with consideration for five main types of cardiac blood supply [4]. The state of heart cavities and parietal endocardium was evaluated by postmortem contrast cardioventriculography [3]. In parallel with CA, MB were visualized by detailed macro- and micropreparation of the myocardium under a stereomicroscope. Histological, spot histotopographic, and morphometric methods were used.

RESULTS

The incidence of MB was maximum in two median segments of CA (44.4 and 40.3%, respectively) and minimum in the proximal (9.7%) and distal (5.6%) segments. These values are the means for the three studied CA. The highest incidence of MB was observed in the anterior interventricular branch of left CA (78 cases), with predominant localization in the 2nd and 3rd segments (48.7 and 38.5%, respectively) and rarely in the 1st and 4th segments (7.7 and 5.1%, respectively). The incidence of MB in the circumflex left CA was 2-fold higher than in the right CA (44 and 22 cases, respectively), the majority of MB being detected in the 2nd and 3rd segments of these CA: 27.3 and 54.5% cases in the right CA and 45.5 and 36.4% cases in the circumflex left CA, respectively. It is also noteworthy that segments of the major CA crossed by MB were less involved in atherosclerotic process. No obstructive atherosclerotic lesions were found in the crossed segments, and in 27.8% cases there were no atherosclerotic changes in the CA intima, while in 18% pronounced dilatation of these CA segments was observed.

The results coincide with published reports indicating that MB in a certain way "protect" CA from atherosclerosis [13] due to constant motion of individual CA segments caused by systolic contractions of MB. These forced movements of CA walls have a specific effect on coronary perfusion promoting dilatation and reducing the effects of sclerotic factors [13,14].

Location of MB in the studied CA determine the changes in the coronary system of the heart. When MB were located in the first segments of the left CA vessels, focal stenoses were associated with limited collateral blood flow in CA branches (Fig. 1, *a*), while

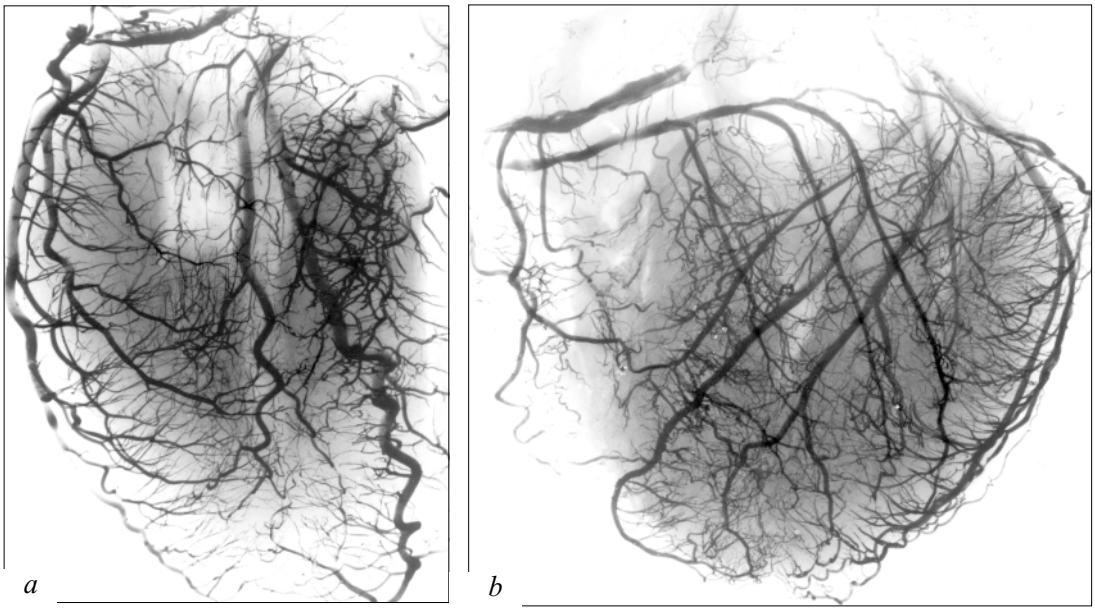

Fig. 1. Focal stenosis of the 1st (*a*) and 2nd (*b*) segments of the anterior descending branch of the left coronary artery. Fragments of coronarograms of patients aged 36 (*a*) and 40 (*b*) years. *a*) markedly limited collateral blood flow and complete patency of coronary branches, myocardial bridges in segments not involved in atherosclerosis; *b*) pronounced myocardial hypervascularization in the presence of myocardial bridges.

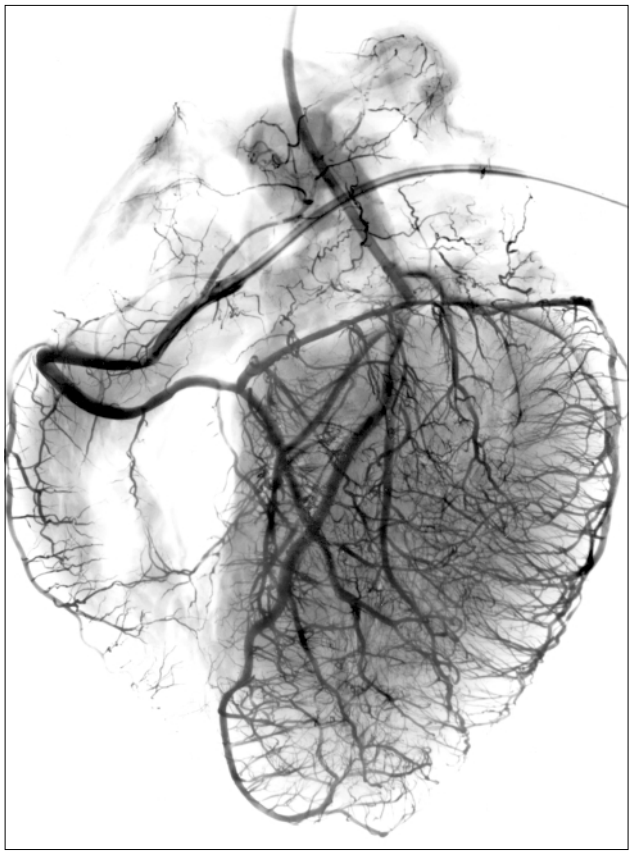

Fig. 2. Focal stenosis of the 3rd segment of the anterior descending left coronary artery with manifest intercoronary steal syndrome under conditions of myocardial bridges. Fragment of coronarogram of a 38-year-old patient.

the distal segments of the corresponding CA remained patent. If MB were located in the second segments of the vessels of the same coronary basin, stenoses were associated with pronounced vascularization of the adjacent myocardial areas, dilatation and patency of the main CA, and collateral capillary plexuses (Fig. 1, *b*). The presence of MB in the third segment of the left coronary basin promoted the development of steal syndrome [4] ensuring essential regional accessory or reserve blood flow (Fig. 2). In some cases the presence of MB in CA segments free from atherosclerotic lesions was associated with compensatory poststenotic dilation (Fig. 3). Such phenomena were most often observed when MB were simultaneously present in different segments of two CA of the left coronary basin. This was also associated with intracoronary steal syndrome.

Analysis of the incidence of MB and coronarographic picture and their correlation with the predominant type of blood supply to the heart showed that MB predominated in the group with median left type (68% cases); median right blood supply of the heart was detected in only 8% cases. Maximum association of MB with median left blood supply was due to involvement of the compensatory collaterals and anastomoses of the main right and left CA, united by the posterior interventricular branches, and of their circumflex branches in the coronary circulation. In cases with median left blood supply, MB crossed mainly the median segments of the anterior interventricular and circumflex branches of the left CA. In cases with median right blood supply MB crossed various segments of the right CA without preference of certain segments.

Cardioventriculography showed hypertrophic changes in cardiac ventricles with essential hypertrophy of predominantly left ventricular wall and ventricular septum in patients with MB. Disproportional hypertrophy of not only ventricular septum, but of the walls of left ventricle was observed. As a rule, MB were detected in myocardial sites without clear-cut topography of muscle layers and presented as muscle bundles consisting of parallel fibers. These bundles tightly adhered to CA wall and formed a peculiar fossa and intramural plunging of an individual segment. In some cases ventricular septum of the heart notably modified the geometry of the left ventricle, making its

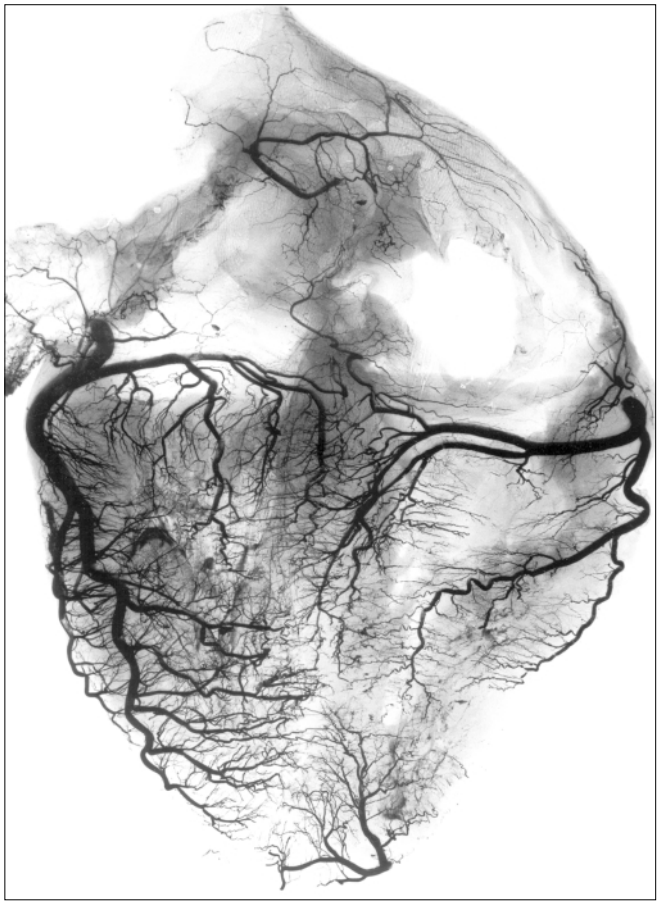

Fig. 3. Focal stenosis of the 1st segment of the circumflex and 3rd segment of the left coronary artery with poststenotic dilation changes in the presence of myocardial bridges. Fragment of coronarogram of a 34-year-old patient.

anterior wall wavy and promoting an intramural position of some segments of the anterior interventricular branch of the left CA.

The hypertrophic variant of cardioventricular changes and the most prevalent median left type of blood supply make the anterior descending branch of the left CA particularly important in myocardial blood supply, thus notably augmenting the effect of systolic compression caused by MB. This effect, leading to pronounced myocardial ischemia of predominantly posterior left ventricular wall and paradoxical blood ejection from CA not involved in atherosclerosis, often leads to the development of severe angina pectoris running a peculiar course, different forms of acute myocardial infarction, and sudden death [1,10]. We also observed a high incidence of sudden deaths in the group with MB (37.5% cases). The effect of systolic compression should be borne in mind in patho- and thanatogenesis schemes for patients with various forms of coronary disease and in specific therapy and prediction of the disease outcome [7,15].

Hence, the incidence and morphological features of MB indicate their important role in the pathogenesis of coronary heart disease. As special and peculiar risk factors, MB can impair coronary circulation in intact CA or in CA without complicated obstructive atherosclerotic lesions. Pathognomonic relationship between MB and type of cardiac blood supply, segmentary topography of the main CA, geometry of the left ventricle, and changes in the cardiac coronary system can serve as the basis for more reliable pathomorphological diagnosis of this phenomenon and correct interpretation of patho- and thanatogenesis factors of sudden death in coronary patients. These data can also be used for evaluating the results of life-time selective coronary angiography in various forms of coronary disease with differential diagnostic and prognostic purposes. Pathomorphological characteristics of MB should be taken into consideration in surgical correction of the resultant disease.

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