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Pathomorphological Peculiarities of Coronary Artery Ectasias and Their Role in the Pathogenesis of Sudden Cardiac Death

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Polypositional postmortem contrast coronarography and pathomorphological analysis were used to study 400 cases of atherosclerotic, postinfarction, arrhythmogenic, and hypertensive heart. High incidence of sudden cardiac death was established in patients with coronary artery ectasia in atherosclerotic heart. In most cases, ectasias were observed in the anterior interventricular branch of the left coronary artery with dominant localization in the second and forth segments. Correlation was found between the maximum incidence of ectasia in the anterior interventricular branch of the left coronary artery and their maximal length, diameter, and bag-shaped appearance. We determined characteristic alterations in cardiac angioarchitectonics reflecting segmentary location of ectasia reflecting inadequacy of coronary circulation and myocardial ischemia leading to ventricular fibrillation and sudden cardiac death.

Key Words: *sudden cardiac death*; *coronary artery ectasia*; *coronarography; pathomorphology; diagnostic criteria*

Among a large number of factors underlying sudden cardiac death (SCD) the leading role is attributed to electrical instability of the myocardium, reperfusion phenomenon, acute focal damages to the myocardium, abnormalities in the heart conduction system, structural disturbances in the hypothalamus, pronounced changes in metabolism of cardiomyocytes, and individual pathomorphological sings in coronary arteries (CA). The range of these manifestations spreads from the overt atherosclerotic lesions to CA with intact macroscopic features.

Vascular ectasias (abnormal dilations) were frequently detected in cardiac blood vessels after SCD [11]. In patients with atherosclerosis, these ectasias were found not only post mortem, but also during intravital coronarography studies [11]. However, despite the profound role of these anatomic abnormalities of CA in SCD genesis, their pathomorphological alterations are still unknown.

Our aim was to study correlation between the incidence, pathomorphological peculiarities, and diagnostic criteria of ectasias in CA and pathogenesis of SCD in patients with various cardiac pathologies.

MATERIALS AND METHODS

Postmortem study was carried out on the hearts of the patients (n=400) with various cardiac pathologies (atherosclerotic, postinfarction, arrhythmogenic, and hypertensive hearts). These patients died of cardiac decompensation of various etiology (n=332) or SCD (n=68). In 86 of 400 cases, coronarography revealed ectasias in CA (21.5%). In 314 cases, CA had pro-

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nounced atherosclerotic lesions (comparison group). The control group comprised the hearts of humans of comparable mean age (*n*=100), who died of casual reasons and who had no signs of cardiac pathology. Among the patients with CA ectasias, there were men (*n*=56) and women (*n*=30), the mean age being 54.2± 0.2 year. All hearts were subjected to complex pathomorphological examination.

To assess the state of CA, in all cases we employed the originally modified method of polypositional postmortem contrast coronarography alone or in combination with the routine WHO anatomic method [2]. The coronarograms of three major branches of CA (the right, anterior interventricular, and circumflex branches) were recorded in opened and flattened hearts. Each branch was subdivided into four segments with equal area of intimal surface preliminary determined by the routine WHO anatomic method.

In parallel to postmortem study of cardiac angioarchitectonics, CA with ectasias were examined using anatomical and coronarography methods. The anatomic shape of the ectasias, their length and diameter were determined by vascular morphometry methods for each basic CA and its segments. Each case of SCD in patients with ectatic CA was compared with the dominant clinical manifestations characteristic of the examined cardiac pathology. Visual histotopography was also used to characterize CA ectasias. The results were analyzed statistically using Student's *t* test for paired samples.

RESULTS

In individuals with CA ectasias, SCD occurred most frequently (76.5%), if the hearts had atherosclerotic lesions (*n*=34, Table 1). In these cases, angina pectoris prevailed in clinical picture. It was resistant to therapeutic treatment and needed surgery (*n*=18, 69.2%). In 15.4% cases, this state was complicated by acute myocardial infarction. The individuals with postinfarction heart were second in place among those who died of SCD (*n*=20, 38.5%). In these cases, the incidence of CA ectasias was 26%. These patients had angina pectoris (*n*=10, 50%), cardiac arrhythmia (*n*=4) and cardiac insufficiency (*n*=4).

Among individuals died with arrhythmogenic heart, CA ectasias were documented in 16% cases. Among these cases, 87.5% patients died of SCD. The dominant clinical manifestation in the later cohort was cardiac arrhythmia (*n*=12, 87.5%). In individuals with hypertensive heart, SCD occurred in 8 of 10 cases with ectasias in basic CA. In these cases, the dominant diagnosis was cardiac insufficiency (*n*=4, 50%).

Among cadavers with CA ectasias (*n*=86), SCD was documented in 68 cases (79.1%). In these patients,

TABLE 1. Relations between Incidence of Ectasias in CA, SCD, and Clinical Manifestations in Various Cardiac Pathologies

Cardiac pathology	Total number of observations	Number of CA ectasias	SCD incidence	Predominant clinical manifestations			
				angina pectoris	arrhythmia	acute myocardial infarction	cardiac insufficiency
Atherosclerotic heart	100	34 (34)	26 (76.5)	18 (69.2)	2 (7.7)	4 (15.4)	2 (7.7)
Postinfarction heart	100	26 (26)	20 (38.5)	10 (50.0)	4 (20.0)	2 (10.0)	4 (20.0)
Arrhythmogenic heart	100	16 (16)	14 (87.5)	—	12 (85.7)	2 (14.3)	—
Hypertensive heart	100	10 (10)	8 (80.0)	2 (25.0)	—	2 (25.0)	4 (50.0)
Total	400	86 (21.5)	68 (79.1)	30 (44.1)	18 (26.5)	10 (14.7)	10 (14.7)

Note. Percentage of cases is given in the parentheses.

TABLE 2. Incidence of Ectasias in Individual Segments of Three Basic CA in Relation to Their Size and Shape during SCD

CA	Number of cases	Incidence in segments, %				Length of ectasias, mm ($M\pm m$)	Diameter of ectasias, mm ($M\pm m$)	Anatomical shape		
		I	II	III	IV			bag	spindle	cylinder
Right CA	12	16.7	41.7	33.3	8.3	16.4±0.4	4.2±0.2	2	2	8
Anterior interventricular branch of the left CA	34	17.6	47.1	23.5	11.8	24.4±0.2	5.6±0.4	26	6	2
Circumflex branch of the left CA artery	22	18.2	31.8	45.5	4.5	22.8±0.2	4.8±0.4	8	12	2
Averaged data on three arteries	22.7	17.5	40.2	34.1	8.2	21.2±0.3	4.9±0.3	12	6.7	4.0

the dominant clinical manifestation was angina pectoris (n=30, 44.1%), while incidences of other diseases were lower: cardiac arrhythmia (26.5%), acute myocardial infarction (14.7%), and cardiac insufficiency (14.7%).

Incidence of ectasias in basic CA was different in patients with various cardiovascular diseases. This incidence was maximum in patients with atherosclerotic hearts and pronouncedly surpassed the corresponding values for postinfarction (1.3-fold), arrhythmogenic (2.1-fold), and hypertensive (3.4-fold) hearts. CA ectasia is the most frequent cause of SCD. Most frequently SCD occurred in patients with atherosclerotic heart, while its incidence in individuals with hypertensive heart was far lower. Clinical manifestations preceding SCD [11] have a certain prognostic value [7].

The study of the incidence of ectasias in the individual segments of three major CA revealed the greatest vulnerability of the anterior interventricular branch of the left CA (n=34) with most frequent localization of ectasias in segments II (47.1%) and IV (11.8%, Table 2). The second in incidence were ectasias in the circumflex branch of the left CA (n=22), where they were observed predominantly in segments I (18.2%) and III (45.5%). The incidence of ectasias was minimal in the right CA (n=12), where no predominant segmentary localization of the ectasias was revealed.

A correlation was found between the maximum incidence of ectasias in the anterior interventricular branch of the left CA and their maximum length (24.4±0.2 mm), diameter (5.6±0.4 mm), and predominant bag-shaped appearance (n=26). In the circumflex branch of the left CA, the ectasias were shorter (22.8±0.2 mm) and narrower (4.8±0.4 mm). Most frequently they have spindle shape (n=12). The right CA demonstrated ectasias with minimal length (16.4±0.4 mm) and diameter (4.2±0.2 mm). Predominantly, they had cylindrical shape (n=8). The average parameters of all three basic CA revealed predominant localization of ectasias in segment II (40.2%). Less frequently ectasias were located in CA segments III (34.1%), I (17.5%), and IV (8.2%).

The revealed peculiarities of ectasias in CA are pathognomonic. Differential diagnostics clearly distinguishes them from the congenital, atheromatous, and localized aneurysms or the coronary megadolichoarteries [6] and from the coronary dilation or antiocclusive effect [15]. Previously, the ectasias were found in some basic CA [11]. Most frequently, the ectasias with similar shape were predominantly located in the anterior interventricular branch of the left CA. In our study of 86 patients with ectasias, these abnormalities were observed in two (16.3%) and three (6.9%) basic CA.

Coronary ectasias determined some peculiarities of angioarchitectonics. When they were present in the most vulnerable anterior interventricular branch of the

left CA, the dilatatory alterations were detected in vessels of the left coronary basin. As a rule, the general character of modified angioarchitectonics of the heart is determined by multiple collateral and anastomotic plexuses. These changes of the vascular bed were most pronounced in cases with bag-shaped CA ectasias (Fig. 1).

The presence of spindle-shaped ectasias in circumflex branch of the left CA induced pronounced rearrangement of cardiac vascular network. As a result, the basic CA demonstrated a clear tendency to loose its major transport role, while hypervascularization of the myocardium led to interweaving of vascular clusters in the coronary basin. In this complex interlaced structure, the lateral coronary pathways and additional regions of remodeled coronary blood flow were detected (Fig. 2).

Cylindrical ectasias pathognomonic of the right CA promoted reorganization of cardiac angioarchitectonics with the development of dilatatory vessels in the left coronary basin and with manifestations of hypervascularization symptom. Pronounced changes in the diameter of blood vessels and rearrangement of the vascular network was observed in the right coronary basin, where vascular depletion regions were formed (Fig. 3).

The changes in cardiac angioarchitectonics accompanying the ectasias of various anatomical types make it possible to maintain the dynamic balance between abnormally dilated vascular regions and intact vascular segments. Therefore, the alterations in angioarchitectonics could be considered as the compensatory changes directed at reducing the disturbances in the coronary blood flow [4,8]. However, this feature predominantly reflects the pathophysiological statics, rather than the real dynamics of the coronary basin.

By changing the blood flow and pressure gradient, CA ectasias create the prerequisites for intercoronary

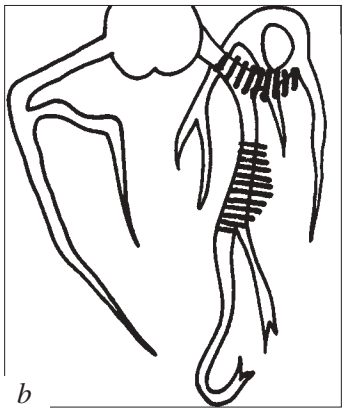

Fig. 1. Bag-shaped ectasias in segment II of anterior interventricular branch and in segment I of circumflex branch of the left CA artery combined with dilatatory alterations of the vessels in the left coronary basin and multiple collateral anastomotic plexes of the small vessels. A fragment of coronarogram of flattened heart. Patient I., 56 years.

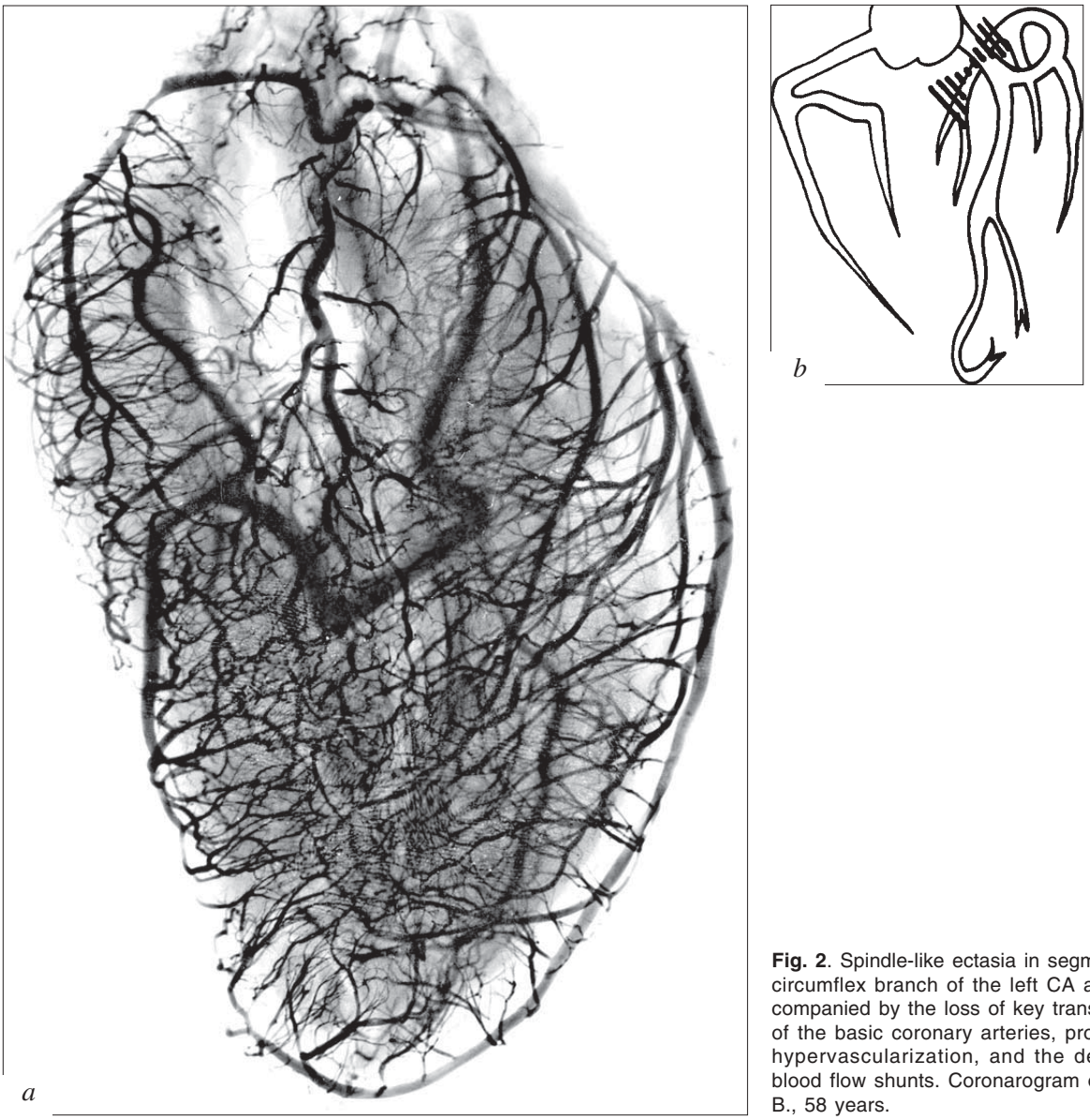

Fig. 2. Spindle-like ectasia in segment III of circumflex branch of the left CA artery accompanied by the loss of key transport role of the basic coronary arteries, pronounced hypervascularization, and the developed blood flow shunts. Coronarogram of patient B., 58 years.

robbery syndrome and transmyocardial shunts of the blood flow resulting in pronounced hemodynamic failures [9]. Due to zonal collateral blockade, these failures frequently lead to the development of distant ischemic foci located at some distance from the concerned vessel [13]. In SCD individuals with ectasias, such ischemic foci developed due to specific redistribution, modification, and moderation of blood supply, rather than due to enhanced oxygen requirements of the myocardium [14].

Myocardial ischemia greatly decreases energy supply to contractile apparatus of the smooth muscles in CA, promotes their specific relaxation that maintains the functional peculiarities of ectasias [10]. Long-term and profound myocardial ischemia inhibits the autoregulatory reactions in CA, which greatly potentiates the extravascular regulation. Probably, coronarography predominantly reveals the passive ectasias in CA. Among changes revealed by coronarography, these ectasias indicate not only pronounced myocardial ischemia, but also the non-vascular state of CA and their segments in patients died of SCD [12].

Local ischemia in the myocardium accompanied by CA ectasias results in its electrical instability, which develops due to concentration gradient of various metabolites across the perfused and non-perfused regions. In its turn, this instability distorts the shape of action potential and accelerates diastolic depolarization [5,7]. As a result, the conduction role of action potential is dramatically reduced, and restoration of myocardial excitability is disturbed. At this stage, arrhythmia was observed, which preceded and promoted ventricular fibrillation, the basic mechanism of SCD in patients with CA ectasias [1,3].

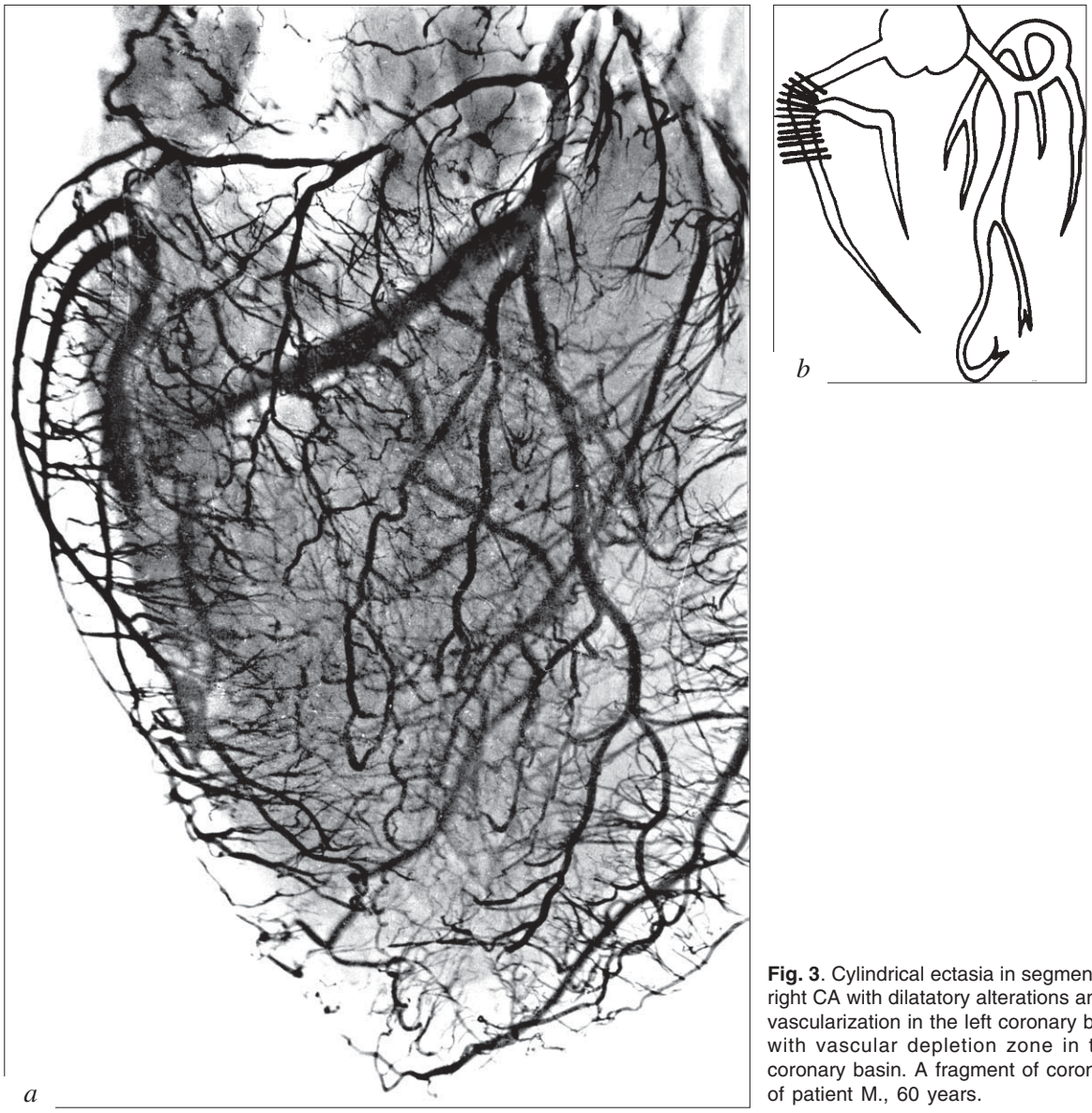

Fig. 3. Cylindrical ectasia in segment II of the right CA with dilatatory alterations and hypervascularization in the left coronary basin and with vascular depletion zone in the right coronary basin. A fragment of coronarogram of patient M., 60 years.

Thus, the complex pathomorphological analysis showed that CA ectasias could be considered as an important risk factor. These ectasias play a significant role in the pronounced disturbances of coronary circulation and lead to specific form of local ischemia in the myocardium, ventricular fibrillation, and SCD. Characteristic incidence of ectasias and their particular relation to segmentary topography of CA with due account of their size and shape create the basis for more significant pathomorphological diagnostics of this phenomenon and for correct interpretation of patho- and thanatogenesis factors in SCD cases.

Selective relations of CA ectasias to various cardiac pathologies and predominant clinical manifestations are important for objective assessment of the data of intravital selective coronarography in differential diagnostics and prognostics.

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