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THE MORPHO-CLINICAL CORRELATIONS OF CORONARY ARTERIES BRANCHES AND THEIR INTRAMURAL PATHWAY

311.01 – HUMAN ANATOMY

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CONCEPTUAL RESEARCH BENCHMARKS

The research actuality

The term "myocardial bridge" means a situation when a part of the coronary artery with a typical subepicardial course is covered over a certain length with a stripe of myocardium, falling into the variants of the intramural trajectories of the arteries of heart [1–3]. This part of the artery can undergo a local systolic compression of varying degrees [4].

According to autopsy studies, the myocardial bridges are found in up to 85% of cases [2.5–7]. In coronary angiography, their incidence varies considerably from author to author, being seen motionless in 0.5-30% of cases [3, 8–11], and when applying provocation tests - in 40% of cases [12, 13]. In patients with hypertrophic cardiomyopathy, complete myocardial bridges are detected in up to 40% of performed diagnostic coronary angiography [1].

Although the vast majority of the myocardial bridges are considered as benign anatomical variants, there is an extensive bibliographic material about the active role of myocardial bridges in the appearance of angina pectoris, spontaneous under the bridge coronary dissection [14], tachycardia and ventricular fibrillation [8, 15–18], transient atrioventricular block, rupture of the interventricular septum caused by myocardial ischemia [19, 20], clinical and paraclinical pattern specific to Takotsubo cardiomyopathy [5, 21].

Of special interest are the reports on the involvement and influence of thick myocardial bridges in the occurrence of acute heart attacks without an associated obstructive coronary artery disease (MINOKA), by the myocardial infarction, under- or proximal to the bridge coronary thrombosis or prolonged coronary spasm [22–24], sudden death of young people caused by major physical exertion, with the intact coronary arteries [25] - especially in cases of high-performance athletes [15] or children suffering from hypertrophic cardiomyopathy [13].

A special attention is paid to the predisposition of large branches of the coronary arteries with an unusual intramural trajectory to be affected or to cause the appearance and evolution of atherosclerotic lesions in various segments of them [26, 27].

The published research reports show the existence of a series of ambiguities and contradictory data about the macro- and microscopic structural features of the variants of the intramural trajectory of heart arteries, classification, etiopathogenetic causes of cardiac ischemia induced by myocardial bridges, their age dependence, gender, coronary type of vascularization, constitutional type, methods of diagnosis and treatment of symptomatic myocardial bridges [28.2].

The problem of the intramural trajectory of the coronary vessels is not limited to the myocardial bridges, being involved in different variants of musculovascular correlations - complete, incomplete myocardial bridges, myocardial tunnels.

The purpose of the research. Evaluation of morpho-functional features of variants of atypical intramural trajectory of coronary arteries.

Objectives:

1. Study of the individual anatomical variability of large subepicardial coronary arteries highlighting the atypical intramural trajectory variants;
2. Establishment of the segments of the coronary arteries with predisposition to atherosclerotic lesions and determination of the correlation with the variants of the atypical intramural trajectory of the coronary arteries;
3. Evaluation of the morphological aspects of the variants of the intramural trajectory of the subepicardial coronary arteries, especially of the myocardial bridges;
4. Determination of the angiographic and functional features of the variants of the intramural trajectory of the coronary arteries;
5. Argumentation of the role of the morphological substrate of the variants of the intramural trajectory of the coronary arteries in the occurrence of myocardial ischemia.

Scientific novelty of the research

A morpho-functional study was performed with the purpose to analyse the epidemiological and morpho-functional aspects of the variants of the atypical intramural trajectory of the coronary arteries. The current research presents an attempt to assess the individual anatomical variability of

the heart arteries, the correlation between variants of the intramural trajectory and coronary atherosclerosis, some features of the intramural coronary trajectory, including: the anatomical incidence, preferential location, association with other coronary and cardiac variants, peculiarities of structure and arrangement of the myocardial bridges, characteristic of the under the bridge perivascular space, structure of proximal-, under- and distal the bridge arterial portions, aspects of the trajectory of the perivascular nerve bundles in the intramural portion.

We have proposed our own classification of the variants of the intramural trajectory of the coronary arteries. The intramural trajectory variants were analysed complexly, at macroscopic, macro/micro- and microscopic level. The obtained data were compared with the data of functional evaluations, which allowed to assume why not all myocardial bridges are clinically manifested and what is their impact on coronary circulation.

Theoretical importance

The results of the current research allowed the epidemiological assessment of the variability of coronary arteries, the incidence and degree of coronary atherosclerotic lesion, the incidence, and types of variants of the intramural trajectory of heart arteries in the population of the Republic of Moldova.

The obtained data are the result of the multi-aspectual, morphological, and functional approach to the variants of the coronary intramural trajectory and facilitate the highlighting of the morphological and pathophysiological determinants in the case of the variants of the intramural trajectory of the coronary arteries. During the study of the variants of the intramural trajectory of the coronary arteries, were determined the potential structural features with ischemic and anti-ischemic coronary effect.

The obtained results of the study give an accumulation of sufficient knowledge to differentiate the typical and atypical variants of the intramural trajectory of the coronary arteries, positioning some of them in the category of structures that can influence the myocardial perfusion.

The applicative value of thesis

Identifying the role of variants of the intramural trajectory of the coronary arteries allows the positioning of the myocardial bridges in the category of structures that, at a certain stage and having a certain morphological parameter, can damage the myocardial perfusion. The results of the study encourage the use of classical macroscopic and macro-micro- as well as microscopic methods in determining the morphological features of myocardial bridges. Among the multiple morphological features found out within the study is the identification of structural features with ischemic and anti-ischemic effects of myocardial bridges.

Determination of variants of origin, trajectory, size of coronary arteries and their branches allows safe handling of medical devices during endovascular procedures on the arteries of the heart.

The obtained results made it possible to create a clear image regarding the possible ischemic role of the variants of the intramural trajectory depending on the topography and the degree of coronary systolic compression.

The approached topic made possible the differentiation of the coronary variants of atypical and typical intramural trajectory.

Implementation of scientific results

The study of the morphological and morpho-clinical aspects of the intramural trajectory of the coronary arteries was initiated and started in 2007 within the primary university cycle of medical training.

The morphological peculiarities of the intramural trajectory of the coronary arteries were presented in 2011 within the license thesis carried out at the Department of Human Anatomy and entitled as *Morpho-clinical features of the intramural trajectory of the coronary arteries.*

Subsequently, in 2015, within the thesis of Master of Human anatomy: *Peculiarities of branching and structure of large coronary arteries and their correlation with atherosclerotic lesions,* were presented data of the variants of coronary arteries, the association of the coronary artery variants with those of the intramural coronary trajectory.

At the same time, the scientific data, obtained in the period of 2007-2019 were generated by the research activity within two scientific research projects: national project for young researchers of *Morphology of myocardial bridges and it's clinical correlations*, during the years 2012-2013, and bilateral international research project 2015-2016, carried out in partnership with Grodno Medical University, Republic of Belarus – *Morpho-clinical aspects of the valvular apparatus of the heart and large coronary arteries*.

The results of the current study are used in the scientific-didactic process of the Department of Anatomy and Clinical Anatomy of State University of Medicine and Pharmacy "Nicolae Testemitanu" and in the scientific activity of the Centralized Pathological Anatomy Department within the Public Medical-Sanitary Institution for Scientific Research in Maternal and Child Health Care.

1. RESEARCH METHODOLOGY

The scientific work was carried out at the Department of Anatomy and Clinical Anatomy of the „Nicolae Testemitanu" State University of Medicine and Pharmacy. The research was conducted during 2016-2018 in accordance with the Principles of the Helsinki Declaration - WMA Declaration of Helsinki – Ethical Principles for Medical Research Involving Human Subjects. The research methodology was approved in „Nicolae Testemitanu" State University of Medicine and Pharmacy, Scientific Council „Nicolae Testemitanu". The study was approved by the Research Ethics Committee of the „Nicolae Testemitanu" State University of Medicine and Pharmacy, no. 55 from 03.06. 2016.

The study was divided into 3 research parts (figure 1).

Compartment I - morphological study. The representative research group was calculated in the EpiInfo 7.2.2.6 Program, „StatCalc - Sample Size and Power" section for analytical study, based on the following parameters: the confidence interval for 95.0% of significance of the results; statistical power - of 80.0%; the incidence in the morphopathological studies of the variants of the intramural trajectory, especially of the myocardial bridges being on average up to 65.0%; result: for the 95% of the confidence interval the calculated value is 20, the effect design (nx8: age / sex / visible macroscopic myocardial infarction / heart size / the thickness of the left ventricular wall / coronary artery branch abnormalities / presence of the variants of coronary artery intramural trajectory) = 160 and with 10.0% non-response rate n = 176.

Within the study, were examined 200 human hearts and fragments of coronary arteries in accordance with the inclusion and exclusion criteria.

As criteria for inclusion served the undried and dried human heart, myocardial flaps with the attached coronary arteries in a preserved and satisfactory condition, without obvious signs of decomposition that would exclude the possibility of anatomical preparation and analysis of anatomical structures of interest.

As exclusion criteria were the organs and fragments of tissue that were in condition of putrefaction which didn't allow the anatomical dissection and isolation of structures of interest.

At the macroscopic level, were studied the morphological and vascularization peculiarities of the hearts.

At the microscopic level, the three variants of vessel location were studied and analysed separately: pontine, semi-pontine and tunnelling. The obtained sections were stained with ***hematoxylin-eosin; picrofuchsin according to Van Gieson; orcein according to Unna-Toenzer in own modification, Tașnic M. et al. (2011).***

The detection of the microstructure of the neurovascular elements in the objects of interest was done by using the ***silver nitrate impregnation techniques after E.I. Rasskazova in own modification, Tașnic M. et al. (2010).***

The macromicroscopic study was performed by selective staining of subepicardial neurovascular elements from integral anatomical pieces performed ***with Schiff's reagent*** in prescription of M.G. Shubin and A.B. Hodos (1964, 1971).

Compartment II. The analysis included all the coronary angiography performed for 1 year (2012) at Institute of Cardiology, in total – 400 reports.

Based on the descriptions in the reports of coronary angiography, it was determined the branching and size variations of the subepicardial coronary arteries. It was established the most frequent localizations of atherosclerotic lesions of the coronary arteries.

Compartment III. The required number of patients with angiographically significant myocardial bridges, which were studied, and was determined, based on the formula used to calculate the volume of the representative sample: n = P (1 - P) (Zα / e) 2; e – error (e = 0.025), Zα - the value of the coefficient Zα = 1.96 for the 95.0% confidence interval of the significance of the obtained results; P – according to bibliographic data this phenomenon – angiographically significant myocardial bridges, is found on average up to 1.0% of cases (P = 0.01). When introducing the data in the formula we obtained: n = 0.01 x 0.99 (1.96 / 0.025) 2 = 60.85, design-

effect (nx4: age, concomitant diseases, results of paraclinical investigations, gender) n = 243.4 and with a rate of 10,0% non-response n = 268. The current study included 331 cases of patients with myocardial bridges, which is a representative sample obtained by the retrospective analysis of 6168 reports of coronary angiography. The analysed coronary angiographs were performed from 2012 to 2019 at *Medpark* International Hospital. All the patients with myocardial bridges determined on coronary angiography were included in criteria of the study. The obtained scientific results were collected and included in the Excel systematization table, with their further processing through the descriptive statistical analysis based on SPSS 22.

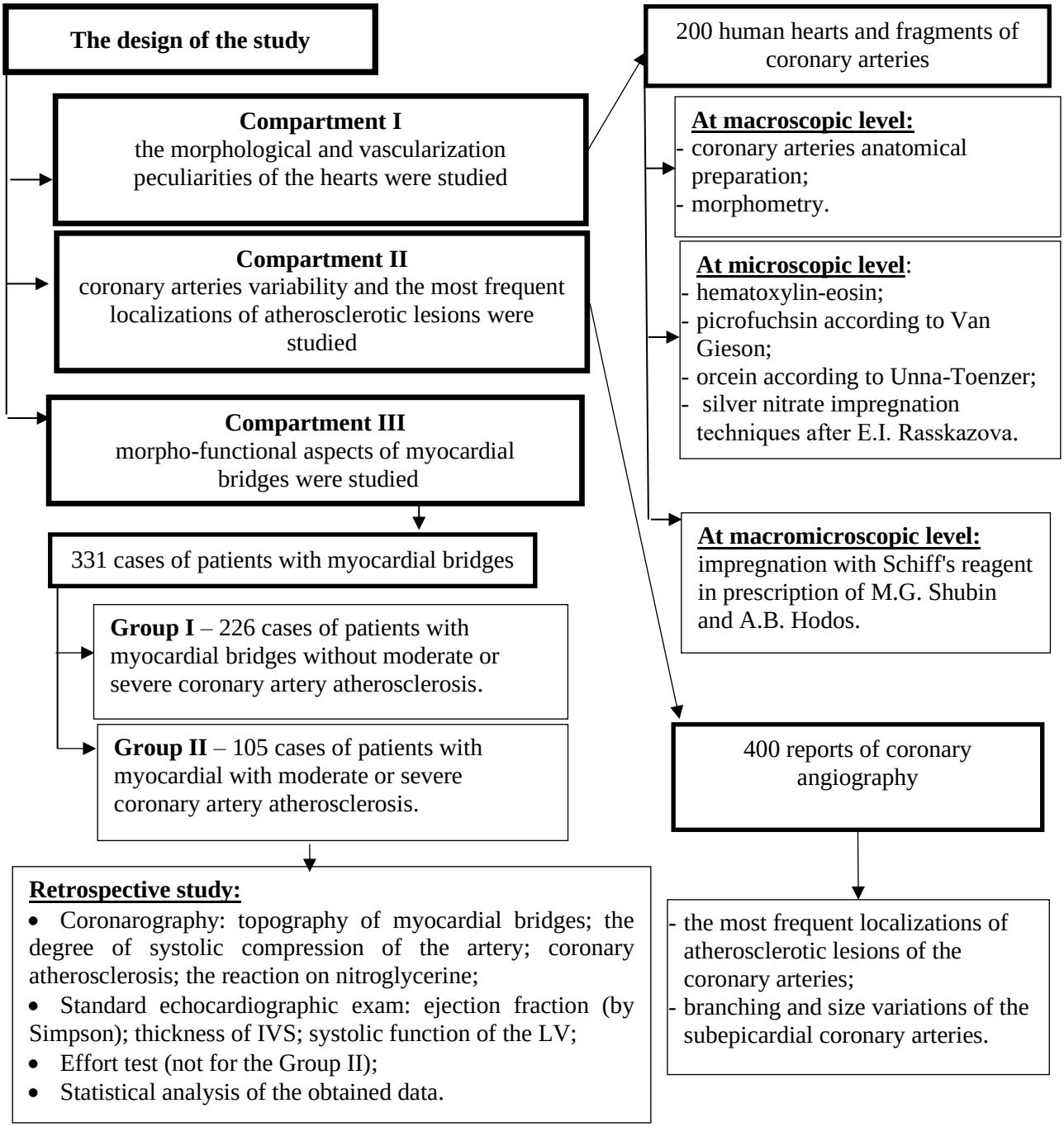


Figure 1. **The design of the study**
Note. LV – left ventricle; FE – ejection fraction; IVS – interventricular septum

2. STUDY OUTCOMES

2.1. Morphological aspects of coronary variability

Within the performed morphological study were described and classified the variants and anomalies of the coronary arteries, detected on 200 hearts and fragments of coronary arteries and after the analysis of 400 coronarography reports.

In the vast majority of the analysed cases reported in the coronarographies, predominated the right type of vascularization, provided by the right coronary artery – 70%, the circulatory bed with left predominance and balanced type being assigned in 19% and 11% of cases respectively, which differs from the study data, performed on formalized anatomical parts (in 47% of cases dominated the right type of heart vascularization, in 41.5% – the left type, and in 11% – the balanced (intermediate) type of heart vascularization).

Out of the total analysed anatomical pieces, only 3 cases were established as of the abnormal origin of the coronary arteries, one of which, described as a very rare, and is the anomaly of origin of the left coronary artery from the pulmonary trunk – Bland-White-Garland Syndrome.

The left coronary artery (LMCA). The main trunk of the left coronary artery in 89% of cases had the medium diameter and only in 11% had a greater thickness. In 52% of cases, the length of the main trunk was assessed as a short, in the rest of coronarographies (48%) – as long.

The anterior interventricular branch (AIB). In 96% of the studied cases, the anterior interventricular branch had a medium diameter and only in 3.5% of the analysed coronary angiograms – large.

In 50% of cases, from the anterior interventricular branch, originated 2 diagonal branches (DB), in 30% - three arteries and only in 19% a single diagonal branch. The diameter of the diagonal branches varied widely from case to case. Thus, the DB I, present in all analysed cases, in 66% of cases had a medium diameter. The DB II, described in 77% of the analysed coronarographies, as well as the DB I in most cases with medium diameter – 65%. The DB III was detected in only 27% of the analysed coronary angiograms, and in 44% of cases, had small dimensions, the same incidence presented cases with vessels of medium diameter - 38%.

The intermediate branch (IB). It is one of the most variable arteries of the heart; it was detected in 48% of cases with a medium diameter in 50% of the analysed angiography reports.

The circumflex artery (CxA). In 88% of cases, the circumflex branch had a medium diameter, giving start to 1-4 marginal branches. Thus, in 58% of cases, from the circumflex artery began 2 marginal arteries, in 28% – 3, and only in 18% and 1% – 1 and 4 branches.

The marginal branches (MB) are characterized by a fairly pronounced numerical variability. Thus, in 50% of cases, were detected 2 marginal branches, in 28% – three, less often, one marginal branch and very rarely – in less than 5% of cases – 4 marginal branches.

The diameter of the marginal branches was characterized by the increased variability. Thus, for marginal branch I, present in 96% of cases; half of them had a medium diameter.

The marginal branch II, detected in 78% of coronary angiography studies, in 54% of cases had a medium diameter.

The marginal branch III detected in only 27% of the studied cases, in most cases (42%), had a large diameter.

The right coronary artery (RCA). The right coronary artery was characterized by more evident stability in terms of the degree of division and trajectory. Only in one case the artery presented ramification.

Variation of the trajectory of the coronary arteries. The curvature of the coronary arteries and their branches were carefully studied, as the one of the morphological factors that can influence the cardiac perfusion and contribute to the development of coronary atherosclerosis. The anterior interventricular branch was selected as the reference vessel, as an artery with the most frequent anatomical and pathological implications.

To assess the degree of corrugation of the coronary vascular elements, they were classified/differentiated 3 degrees of convexity of the coronary arteries branches: Grade 0 – linear coronary arteries, without undulations or flexures; Gr I – coronary arteries with slight undulation, arched arteries; Gr II – serpentine arteries, with 3 subgrades of flexures, respectively: A – coronary flexures only in the distal third of the anterior interventricular branch; B – flexures including the distal and middle thirds of the anterior interventricular branch and C – flexures and curves involving all segments of the anterior interventricular branch.

Structural abnormalities of the coronary arteries. The coronary aneurysms and ectasias were described as structural abnormalities.

In cases of atherosclerotic pathology of the heart arteries, aneurysmal dilatations of the prestenotic or poststenotic coronary arteries (predominantly in the coronary atherosclerotic pathology) can be often detected.

2.2. Coronary atherosclerosis

It was analysed the degree and location of atherosclerotic stenosis in correspondence with the portions of the most important vessels of the heart.

The left coronary artery. An expressed degree of stenosis – more than 50%, was determined in 24.3% of cases, which represents 4.25% of the total number of patients subjected to the study, the rest of the patients had atherosclerotic narrowing that didn't exceed 50%.

The anterior interventricular branch was affected by atherosclerotic plaques in 41.5% of the analysed cases, AIB II – in 42.5%, and AIB III – in 17% of the analysed patients. From the total number of stenoses – 27% were located on the AIB I trajectory. Advanced stenoses (more than 75%) were registered in about 12% of the total group. In 7.2% of cases AIB I was occluded – representing 3.25% of the total study group. The severe stenoses on the anterior interventricular branch trajectory, in its middle segment, were detected in 24.49% of cases of atherosclerotic lesions of this vessel, which is 6.5% of the general study group.

The diagonal branches. The atherosclerotic damage of the diagonal branches constituted 40% for DB I, 18% for RD II and 3.25% of cases for DB III.

In 21% of cases, the lumen of the diagonal artery I presented a stenosis, which reduced the diameter of the vessel by more than 75%, representing 8.25% of the total analysed protocols.

For DB II, the substantial reduction of the vascular lumen constituted 8%, which is 2.75% of the analysed group. The distal diagonal branch is characterized by a major reduction of lumen diameter in 23% of cases, which is 0.75% of the studied cases.

Occlusions at the level of diagonal branches were detected in 1% for DB I, 0.75% of cases for DB II, and in no case for DB III.

The right coronary artery. The atherosclerotic damage in these segments were reported in 27% of cases for RCA I, 46% for RCA II and 20.5% for RCA III.

Severe lesions along the proximal segment of the right coronary artery were detected in approximately 13% of cases, which is 3.5% of the general study group. In 10% of cases, respectively – 2.75% of all analysed protocols, the right coronary artery was occluded in its proximal segment.

The middle segment of RCA was severely affected by atherosclerosis in approximately 21% of all cases of atherosclerotic impairment of RCA II, which is 10% of the total number of analysed cases. In 18% of cases RCA II was occluded, representing 8.5% of the analysed cases.

In 24% of cases, RCA III presented severe stenoses on its trajectory, which represents approximately 5% of the general group. Chronic occlusions were detected in 20% of cases with RCA atherosclerosis (4.25% of the general group).

The intermediate branch. One of the most variable arteries of the heart was found in 48% of cases and in 50% of the analysed coronary angiograms it has an average diameter. In 16% of cases the intermediate branch was affected by atherosclerotic lesions, of which 27% of cases of atherosclerosis reduced the lumen of the vessel by more than 75%, which is 4.5% of the total study group. In 1% of all analysed protocols, the intermediate branch was absent.

The circumflex branch. In 36% of cases, the coronary atherosclerosis was localized in the proximal segment of the circumflex artery, and in 23% of cases in its' distal segment. In 18% of cases, atherosclerotic lesions were reducing by 75% the vessel diameter. The distal segment was presenting major stenoses in 23% of cases or 5.5% of the general group. Cases of occlusion of the proximal or distal segment accounted for 3.4% and 17.8% of cases, respectively, representing 1.25% and 4.25% of the studied angiography reports.

The marginal branches. Marginal coronary lesions were detected in 24% of cases for marginal branch I, 16% in the case of marginal branch II and only in 8% of radiological images in the case of marginal branch III.

The frequency of the significant lesions for marginal branch I was 27%, 6.75% of the total number of examined cases. In the case of marginal branch II, stenoses exceeding 75% constituted 37% or 6.7% of the general study group. Marginal branch III presented major stenoses in 31% of cases – 1.5% of all studied cases.

The frequency of occlusions in marginal branch I was 5%, 16% in the case of the second marginal branch and 6% in the case of the third branch.

The posterior descending branch (PDB). Regarding the posterior descending branch, atherosclerotic lesions were detected in 5.25% of cases, of which 14.3% were lesions of 75-90%, representing 0.75% of the total number of studied cases. The occlusions of this branch were established in 0.5% of all studied cases.

2.3. Variants of the intramural trajectory of coronary arteries branches

The complete myocardial bridges were described in 62% of the analysed hearts. In 29% of cases, incomplete myocardial bridges were described, and in 47% of the evaluated hearts – myocardial tunnels were identified. Frequently, several variants of the intramural trajectory were detected on the arteries of the same heart.

The complete myocardial bridge represents the position in which a portion of the subepicardial coronary artery, in one or more fragments of its trajectory, enters the myocardium with its subsequent reappearance, after a certain segment of the intramural path, under the endocardium (figure 2).

In the case of **the incomplete myocardial bridges**, the coronary arteries are deep into in a groove formed by the heart muscle, so that their external semicircle is covered only by the epicardium and subepicardial fatty tissue.

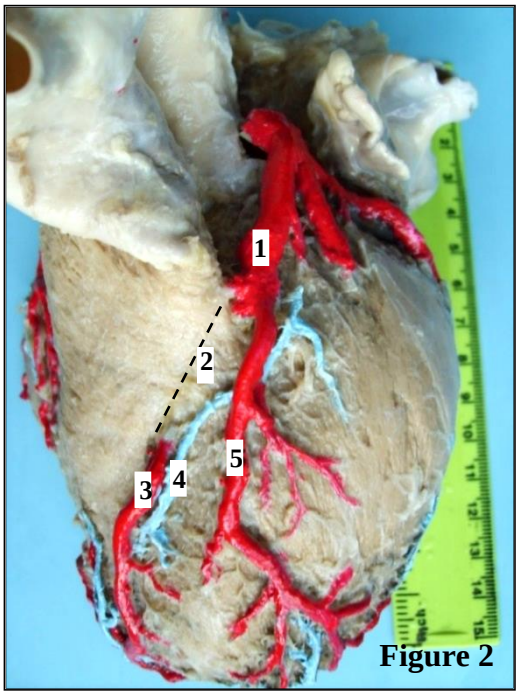
The myocardial tunnels are structures in which the vessel, originally placed subepicardial, enters and follows the intramural trajectory without a subsequent reappearance under the epicardium. Thus, we have described typical and atypical myocardial tunnels.

With atypical intramural tunnel trajectory are considered the cases when the entry into the myocardium happens with a branch of large diameter, which in most people has a subepicardial trajectory (example: the entry into the myocardium of the anterior, posterior interventricular branches, marginal or diagonal branches happens in the proximal or middle third of the left ventricle).

2.3.1. Macroscopic study of the intramural trajectory of the heart arteries

The complete myocardial bridges

Most bridges had 2-5 mm of thickness – 62%; in 27% of cases the thickness of the bridges was ≤ 2 mm. The thick myocardial bridges of 6-9 mm were described in 15% of cases, and the very thick myocardial bridges, with a thickness of more than 10 mm – in 3% of cases. The thick myocardial bridges, up to 1 cm, were found exclusively on the trajectory of the middle third of the anterior interventricular branch. Unique cases of localization of the under the bridge arterial segment in the immediate adjacency of the left ventricular cavity were detected (figure 3).



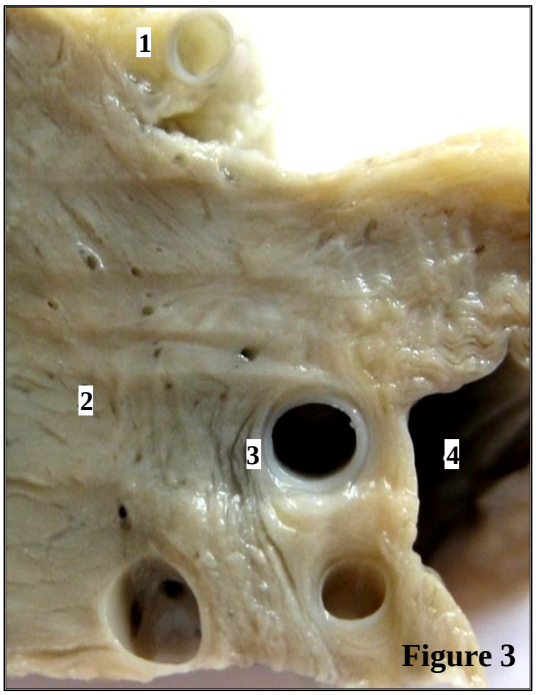


Figure 2. **Complete myocardial bridge located on the middle third of the anterior interventricular branch.**

1 – proximal to the bridge segment of AIB; 2 – complete myocardial bridge; 3 – distal to the bridge segment of the anterior interventricular branch; 4 – vena cordis magna; 5 – diagonal branch II. Macroscopic object. Ob. 32.

Figure 3. **Under the bridge segment of AIB in the middle third of the vessel in cross section. Thick myocardial bridge. Location of AIB in the adjacency of the left ventricular cavity. Cross section.**

1 – the diagonal branch with subepicardial location; 2 – septal myocardium; 3 - the under the bridge segment of AIB; 4 - left ventricular cavity. Macroscopic object. Ob. 39

The range of width of complete myocardial bridges varied widely. In most of them, the revealed complete myocardial bridges had a width of 10-30 mm (34%) and 31-50 mm – 36%; in 16% of cases the width of the bridge exceeded 51 mm, and in 12% of cases the bridges had 10 mm in thickness.

Predominantly, the complete myocardial bridges covered the anterior interventricular branch, succeeded by the diagonal branches, the marginal branch I and the posterior interventricular branch. Only in one case the complete myocardial bridge was detected on the trajectory of the right coronary artery and its branches.

The study showed that CMB on AIB, most frequently, covered the distal portion of the proximal third, the proximal and the middle portions of the middle third of the vessel (86% of cases with CMB located on AIB). Less often – in 32% and 26% of cases, CBM covered the distal and, respectively, the proximal third of AIB.

In 75% of the studied hearts, on the same organ, could be detected several complete myocardial bridges. In 33% of cases were detected 2 CMBs, in 18% of cases – 3 myocardial bridges were located on one heart, and in 3% of cases – 4 and more bridges.

The incomplete myocardial bridges

These types of bridges have been called „incomplete" since they don't have a myocardial band that would cover the upper part of the coronary artery wall (as in case of myocardial bridges). The vessel is surrounded by the myocardium from lateral and posterior parts.

The frequent association of the complete myocardial bridges with the incomplete ones in conditions of „gradual immersion" of the vessel in the myocardium at the entrance of the artery under the myocardial bridge, avoids the formation of flexions and marked arterial angles.

The classification of incomplete myocardial bridges is similar to the complete myocardial bridges' one: based on their width (wide / narrow) and the type of the involved vessel - arterial/venous/ arteriovenous.

As well as in case of complete myocardial bridges, the width of the incomplete myocardial bridges varied within a wide range of limits (1-70 mm). The most often were described incomplete myocardial bridges in the range of 11-30 mm; wide myocardial bridges – over 51 mm, were described in approximately 5.5% of cases.

From topographical point of view, in 50% of cases, the incomplete myocardial bridges were detected on the trajectory of the anterior branches of the right ventricle, the anterior interventricular branch being placed on the second place (25%). Less frequently (in 20% of cases), the IMB (incomplete myocardial bridge) were located on the trajectory of the diagonal branches of the left ventricle. On the marginal branch I, the respective structures were found in 12% of all cases in which IMBs were established. They precede the CMB with a width of 5-10 mm. On 24% of the studied hearts, were detected several IMBs per organ. The maximum number of IMBs detected on a heart was 5, and the maximum number of IMBs identified on a vessel were 2.

The myocardial tunnels

From pathophysiological point of view, the object of interest is not only the muscle tunnels that include small arteries, but also those which are related to the large branches, which usually have a subepicardial trajectory. The incidence of myocardial tunnels established within the study is 47%.

In 28% of cases were detected atypical myocardial tunnels, being so called because they include a large-diameter artery, which normally have a subepicardial trajectory, or situations in which large-diameter arteries have an early enter in the myocardium.

The most common atypical myocardial tunnels were found on the trajectory of the diagonal branches of the left ventricle, on the second place – on the trajectory of the marginal branches (figure 5). Muscle tunnels were also detected along the posterior interventricular branch in 10.5% of investigated cases (figure 4).

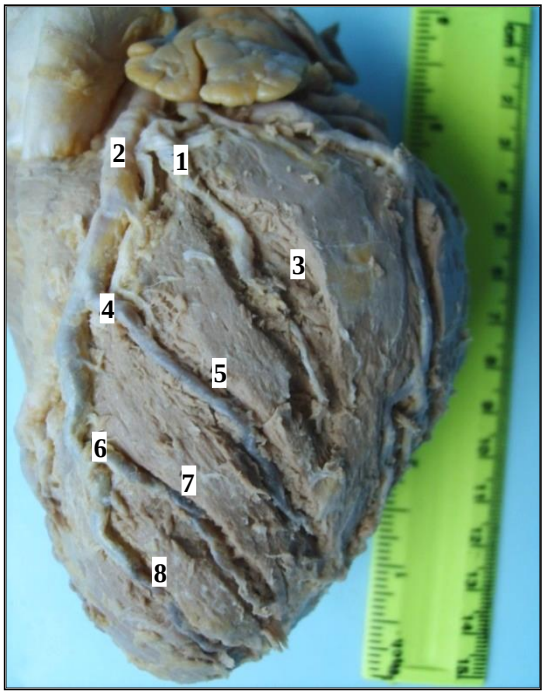


Figure 4. Atypical myocardial tunnels.

1 – the proximal to the tunnel segment of intermediate branch; 2 – anterior interventricular branch; 3 – the tunneled segment of the intermediary branch; 4 – the proximal to the tunnel segment of the diagonal branch I; 5 – the intramural segment of the diagonal branch II; 6 – the proximal to the tunnel diagonal branch II; 7 – the intramural segment of the diagonal branch II; 8 – the diagonal branch III in the muscular tunnel. Macroscopic object. Ob. 35.

Of particular interest is the upper intraseptal branch, which has its' start from the upper third of the upper interventricular branch, enters the interventricular septum, where it branches into thinner terminal vessels.

In the case of systolic stenosis of this branch, determined by the compressive action of the myocardial tunnel in which it is located or in the case of stenosis caused by atherosclerotic plaque of the main trunk of the left coronary artery, it may cause an ischemic process of the anterior papillary muscle of the right ventricle, intraventricular conductivity disorders or tricuspid insufficiency.

2.3.2. The microscopic aspect of the intramural trajectory of the heart arteries

The microscopic aspect of the under the bridge musculovascular complex shows that the term *myocardial bridge* is conventional. Thus, in case of thin myocardial bridges, the orientation of the myocardium covering the vessel corresponds to the direction of the myocardial bundles at the level of the respective muscular layer, and around the vessel forms a thin bridge from cardiac muscles with circular orientation in relation to the artery.

Within the thick myocardial bridges covering the anterior interventricular branch, located in the thickness of the interventricular septum, the myocardial bridge consists of myocardium with helical orientation in relation to the under the bridge arterial segment. At the same time, in the case of the respective type of bridges, we noted the lack of abundant perivascular fatty tissue, the under the bridge vascular segment being almost entirely completed by a network of collagen fibers. Sometimes, at the border with the walls of the pontine tunnel, these fibers may have a circular orientation to the vessel, lining the adjacent myocardium.

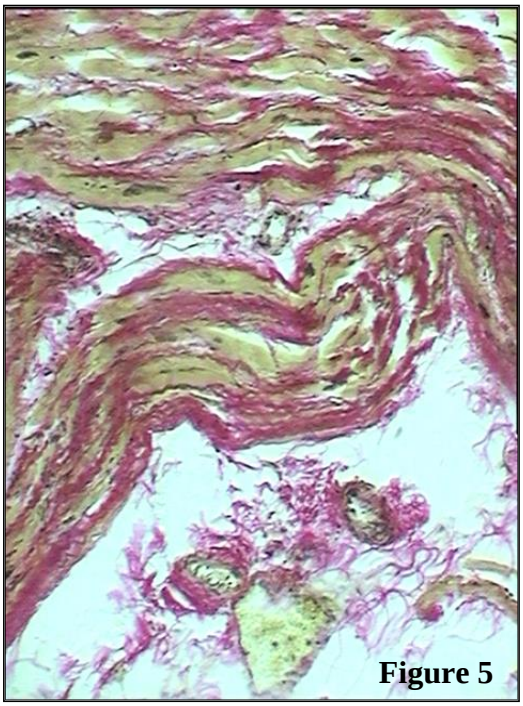
The histological study of the muscle bands showed the structural non-uniformity of the bridge over its entire length. In the initial part of the myocardial bridge predominated the connective tissue and multiple collagen fibers in chaotic orientation, the similar picture presented the thin myocardial bridges. At the same time, with the thickening of the myocardial bridge, the amount of connective tissue is reduced, being replaced by true myocardium.

Often, in the thick CMB, at the border between the myocardium and the adventitia of the artery, were observed collagen fibers with a circular orientation, which are supposed to oppose the systolic compression caused by the myocardial bridge (figure 5).

In the case of thick myocardial bridges, which cover the proximal and middle third of the anterior interventricular branch, were detected multiple isolated nerve cells and microganglions, which included from 10 to hundreds of intensively silver-absorbing neurons in the proximal to the bridge coronary portion.

In several cases, in the structure of nerve cell agglomerations, located in the adventitia of the proximal to the bridge coronary portion, were detected button-shaped receptors (figure 6). The abundance of the receptors in the proximal to the bridge portion of the vessel would play a role in the regulation of vascular diameter depending on the rheological changes determined by the bridge.

Regarding the innervation of the under the bridge vascular segment, no distinctive morphological features were detected.



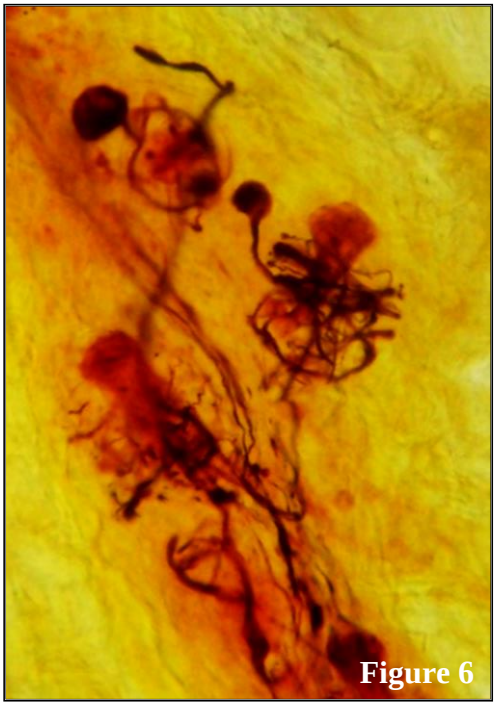


Figure 5**. Circular orientation of collagen fibers at the border between the myocardium and the perivascular space, in case of thick CMB.** Ob. 22. Microscopical view. Staining: picrofuxin staining after Van-Gieson, × 280**.**

Figure 6. **Nerve cells, located on the trajectory of a nerve trunk, intensely surrounded by nerve extensions. Presence of button receptors in the adventitia of the proximal to the bridge vascular segment.** Ob. 23. Microscopical view. Silver impregnation after E.I. Rasskazova, × 400.

By selective staining of the bundles of elastic fibers with orcein in the under the bridge segment of the anterior interventricular branch, it was detected sectorial doubling of the inner elastic membrane, possible in the places of maximum systolic compression of the vessel, playing an anti-compressive role.

2.3.3. Macromicroscopic picture of the intramural trajectory of the heart arteries and associated nerve elements

The evaluation of the perivascular trajectory of the cardiac plexus nerves, applying the selective staining of the total preparations with Schiff's reagent, established the location of the nerve trunks in the immediate vicinity of the under the bridge artery. In this way, the intramural trajectory of the anterior interventricular branch is attracting, in majority of cases, under the bridge not only solitary nerve fibers, but also thicker nerve trunks from the periarterial plexuses (figure 7).

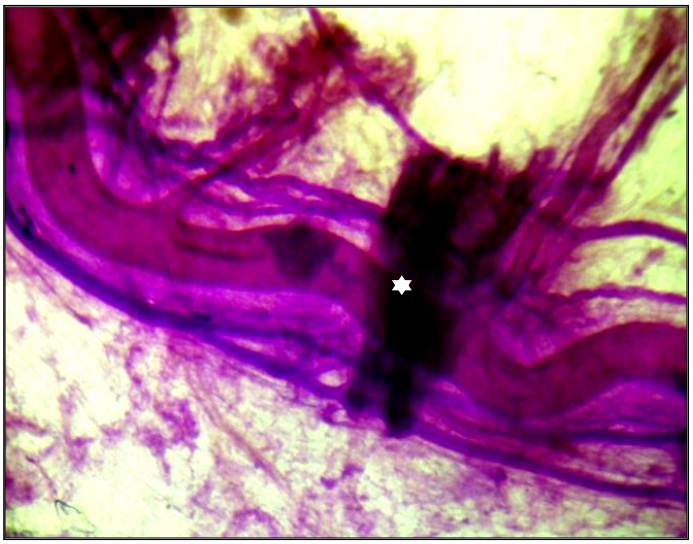


Figure 7. **The under-bridge course of the peri-coronary nerve trunks.** Macro-microscopical view. Ob.63. Staining: use of Schiff's reagent, × 3.

In the case of thick myocardial bridges, we highlighted the persistent under the bridge deformity of the arterial segment. In case of deep under the bridge trajectory, the vessel gets a permanent shape of „saw teeth" or „hourglass", the results being also confirmed by the cross-sections study of the intramural portion of the artery.

2.3.4. The intramural trajectory of the heart arteries in morpho-functional aspect

During the morpho-functional study, from the three variants of the intramural trajectory of branches of the coronary artery, it was possible to identify and describe only the myocardial bridges and some myocardial tunnels**.**

Of the 6,168 evaluated reports, the myocardial bridges were detected in 331 patients, which is 5.3% of the total number of cases.

The significant gap between the morphological and angiographic incidence of determination of myocardial bridges can be explained only by the inability of all the myocardial bridges to reduce the arterial lumen during the systole.

In the group of patients with myocardial bridges – 331 patients, 97% of cases were located on anterior interventricular branch (figure 8), and in 3.6% of cases – on the other vessels: right coronary artery, diagonal branch I, obtuse marginal branch, posterolateral branch (Table 1).

The myocardial bridges on vessels, other than AIB, in most cases, aren't strong enough to compress the vessel, or are thin myocardial bridles, except for a few cases with active systolic myocardial bridges on the intermediate branch, diagonal branch I.

In 65% of the investigated cases, the bridges were in the middle third of the anterior interventricular branch (AIB II), and in 27% – the myocardial bridges were covering the lower third of the artery (AIB III). In 4.23% of cases, the bridges located on the AIB, were defined as extended, covering 2 segments at the same time. The degree of under the bridge arterial systolic stenosis varied largely within 10-95% (Table 2).

The analysis of the degree of systolic stenosis of the coronary artery in the under the bridge segment in patients with clinically and electrocardiographically positive treadmill test, didn't

establish a direct correlation between the degree of the systolic stenosis of the artery and the degree of ST segment elevation during the physical effort. The medium degree of ST-segment deviation caused by physical effort was 1 mm.

The comparative study didn't highlight any interdependence between the degree of under the bridge vascular compression and the degree of hypertrophy of the left ventricular myocardium in the general study group.

Another investigated aspect was the applicability and importance of the nitroglycerine test in patients with myocardial bridges. It was established the augmentation of the grade of the coronary systolic stenosis after intracoronary administration of nitroglycerine by 98% from the initial level.

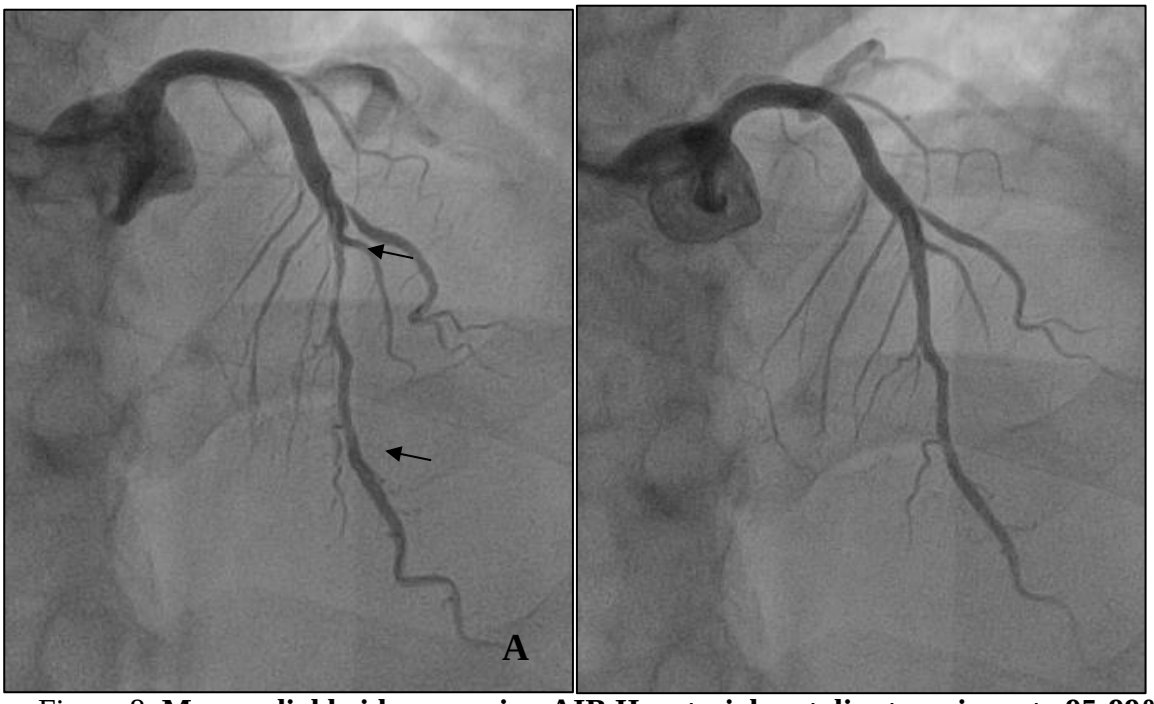


Figure 8. **Myocardial bridge covering AIB II, arterial systolic stenosis up to 95-99%. Note the irregular deformity and narrowing of the artery caused by the myocardial bridge, with a predominance in the proximal and middle part. A – angiographic sequence during the cardiac systole; B - angiographic sequence during the cardiac diastole.** Coronary angiography. Ob. 87.

Table 1**. Topographic distribution of the myocardial bridges in the coronary angiography study group.**

Vessel involved	%
CMB on anterior interventricular branch	97.0
CMB on other vessels	3.6
CMB on right coronary artery	0.6
CMB on circumflex artery	0.3
CMB on diagonal branch	1.8
CMB on marginal branch	0.6
CMB on posterolateral branch	0.3
Combinations of bridges on different arteries	1.8

Table 2**. Variation of the location of the myocardial bridges on the trajectory of the anterior interventricular branch.**

AIB segment covered by CMB	%
Myocardial bridge on AIB I	0.00
Myocardial bridge on AIB II	65.86
Myocardial bridge on AIB III	27.49
Myocardial bridge on AIB II+III	4.23
Isolated myocardial bridge on one of AIB segments	93.35

An important aspect about the myocardial bridges is their role in the development of proximal to the bridge, under the bridge and distal to the bridge coronary atherosclerotic lesions.

From the total number of investigated reports, in 32% of cases were described proximal to the bridge atherosclerotic plaques located at various distances from the myocardial bridge, and only in one case (0.5%) – distal to the bridge, atherosclerotic plaques being located right after the bridge. There were no cases with detected under the bridge coronary atherosclerosis.

Within the study of the myocardial tunnels, excepting the intraseptal branches, *in vivo* activity could not be investigated, due to the impossibility to differentiate the tunnels from the extended myocardial bridges. That's why, we have processed only the intramural position of the first intraseptal branch.

In some cases, it was noticed that during the systole of the heart, a part of the blood column is displaced from the corresponding intraseptal branch, having an aspect of pulsating artery.

The dominance of the superior intraseptal branch in the vascularization of the anterior papillary muscle of the right ventricle was confirmed via coronarography in 15% of cases of the analysed coronarography reports.

In cases of arterial compression of the intraseptal branch, the degree of stenosis of the main trunk of the branch reached 40-50%, and of the terminal branches – up to 70-80%.

3. SUMMARY OF THE OBTAINED RESULTS

The typical intramural coronary trajectory is characterized by the slow, gradual entry of the terminal portions of the diagonal branches, marginal branches, postero-lateral branches, postero-diagonal branches and the intraseptal branches into the myocardium. Usually, this passage of the vessel from the subepicardial to the intramural portion occurs in the middle or distal third of the left / right ventricle, the involved arteries presenting a diameter less than 2-2.5 mm, with gradual increasing of the myocardium thickness covering the vessel.

The typical intramural trajectory doesn't apply to the anterior interventricular branch, the circumflex artery, and to the right coronary artery. These coronary vessels, normally, have only subepicardial extramural trajectory (except for the distal portions), and their location in the myocardium is an atypical intramural trajectory abnormality, due to the large diameter and myocardial portion that can be ischemic in case of severe arterial compression caused by myocardial bridge/tunnel.

The study highlights that within the same examined heart can frequently be combined typical intramural trajectories with atypical ones – complete and incomplete myocardial bridges, myocardial tunnels, suggesting that the early entry of the artery into the myocardium is not an accident or occasional location, but involves a specific development of the arterial system of the heart, an incomplete externalization of the coronary arteries in the organogenesis of the heart, a process of incomplete de-muscularization of the coronary arteries [30].

According to the obtained results – only complete myocardial bridges and myocardial tunnels may have clinical importance as structures that could cause myocardial ischemia by vascular compression in cardiac systole.

The morphological incidence of the detected myocardial bridges was 62%, and the angiographic one, without application of provocation tests – 5.3%. The obtained data is consistent with literature data [31, 32] and shows that not all the myocardial bridges can sufficiently compress the under the bridge coronary segment, thus, not all of them would have an ischemic effect.

Starting from the results of the macro-, micro-, and mesoscopic study, structures with a possible ischemic and anti-ischemic / pro-compressive and anti-comprehensive role on the intramural trajectory of the coronary arteries and their large branches were described. Recently, more references from foreign authors, about the existence of morphological signs that contribute to the appearance and progression of the myocardial ischemia, and those that prevent systolic compression of the coronary artery by the intramural areas, can be found.

Hereunder are listed the corresponding morphological features identified within this study, some of which are also confirmed by the scientific findings of authors from abroad.

As **macroscopic features with ischemic potential** on the intramural trajectory would be:

● a large diameter of the vessel involved under the bridge or atypical, systolic active myocardial tunnel [33];

● the sudden entry of the vessel into the myocardium with the formation of a „loop" of myocardium around the artery at the entrance under the bridge and presence of flexures, angles from the vessel;

● a great thickness of the myocardial bridge [33,34];

● the extension of the myocardial bridge (wide myocardial bridges); branching of the artery under the myocardial bridge [33,34];

● the association of several myocardial bridges and / or myocardial tunnels on the same organ, the presence of proximal to the bridge or pre-tunnel flexures [33].

Macroscopically, among **the protection mechanisms** against ischemia caused by intramural course of coronary artery, in the proximal to the bridged segment, we found:

● presence of incomplete myocardial bridges, which preceded the complete myocardial bridges or myocardial tunnels, due to which a sudden entry of the vessel under the bridge or in the muscle tunnel, is avoided;

● presence of vascular collaterals [34].

Among structural features with **ischemic role in the under the bridge** or intramural segment of the vessel, we found:

● the systolic compression of the vessel by the pontine myocardium or tunnelling myocardium with generation of retrograde systolic blood flow;

● persistent deformation of the vessel at the under the bridge level [35];

● persistent reduction of the lumen diameter of the under the bridge arterial segment, delayed diastolic relaxation and return to the original diameter of the systolic compressed coronary artery [37];

● predisposition to coronary spasm in the under the bridge portion [35];

● permanent crushing of the artery during systole, leading to endothelial dysfunction, with predisposition to under the bridge thrombogenesis [36];

● narrow perivascular space increasing the possibility of compressive action of the myocardial bridge over the under the bridge vessel.

● the presence in the structure of pontine tunnel of myocardial tissue with helical orientation that could compress and shorten the artery during systole, explaining the persistent deformation of the artery and the delay of diastolic perfusion of the myocardium, confirmed by Doppler ultrasound [37–39].

Among the protection mechanisms, in the under the bridge or intramural segment of the vessel, we could list the:

● predominance of connective tissue in the structure of complete myocardial bridges or perivascular myocardium; wide perivascular space lined with fatty tissue [40];

● insufficient thickness of the myocardial bridge, inability to overcome the intracoronary blood pressure;

● presence of connective tissue infiltrations in the form of bundles of collagen fibers circular to the vessel, located at the border with the walls of the myocardium or adjacent to the perivascular space, abundance of the collagen bundles in the under the bridge perivascular space;

● presence of multiple elastic fibers in the adventitia of the vessel;

● doubling of the inner elastic membrane of the artery.

The last three features may act as a shock absorber during the systolic compression of the vessel.

The identification of proximal to the bridge or proximal to the tunnel structures with ischemic potential at the intramural level of the vessel and their contrast with the data described in the literature, provide the theoretical explanation of the proximal to the bridge and intramural functional and rheological changes described by some authors:

● appearance of retrograde systolic flow at the expulsion of the blood column from the under the bridge arterial segment of the vessel during cardiac systole with the interaction of this flow with the anterograde perfusion – a phenomenon that generates a blood flow perpendicular to the vessel walls [41,42];

● rising of local intracoronary pressure and damage of the internal tunica integrity [2].

The proximal to the bridge vascular micro-trauma leads the subsequent formation of proximal to the bridge atherosclerotic plaques; the proximal to the bridge atherosclerotic plaque induces further changes in local hemodynamic, while the under the bridge intracoronary pressure is decreasing the degree of coronary systolic stenosis – a phenomenon described for the first in the current study.

In certain situations, the pro-ischemic effects of the atypical variants of the intramural trajectory of the coronary arteries could be enhanced by:

● tachycardia, which shortens the duration of the diastolic period in combination with the late relaxation of the under the bridge segment of the vessel;

● diffuse or isolated disease of the coronary artery caused by atherosclerosis;

● hypertrophy of the heart walls – in hypertrophic cardiomyopathy;

● anaemia, hypoxia;

● the use of drugs that increase the degree of systolic stenosis of the under the bridge vascular segment.

The *in vivo* evaluation of myocardial bridges and atypical myocardial tunnels, by studying the coronary angiography, identified the most typical location of symptomatic CMB on the anterior interventricular branch, which coincides with the statistics indicated in the scientific papers, but differs from the data of our morphological study [2,43,44].

In the group of patients not severely affected by atherosclerotic pathology of coronary arteries, predominated the insignificant systolic stenosis of the under the bridge arterial segment, while the second group of study (with moderate and severe atherosclerotic lesions) was dominated by moderate systolic compression, and the number of patients diagnosed with severe under the bridge systolic stenosis was double towards the first study group of patients. The obtained results confirm indirectly the launched idea for the first time in the current study, that the distal intracoronary pressure of the severe atherosclerotic lesion and the intracoronary resistance is lower, which leads to reduced under the bridge coronary flow and increasing the compressive effect of the bridge.

In 32% of cases, proximal to the bridge atherosclerotic plaques of different degrees and at different distances from the myocardial bridge were detected, but no correlation was described between the presence of myocardial bridges and the presence of proximal to the bridge atherosclerotic lesions and the degree of under the bridge / intramural systolic stenosis and the degree of proximal to the bridge coronary stenosis. Only in one case (0.5%) the distal to the bridge atherosclerotic plaques were located right after the bridge. No cases of under the bridge coronary atherosclerosis were detected. The obtained data could be different in the case of using the intracoronary imaging techniques in the evaluation of patients with atypical variants of intramural trajectory.

No interdependence between the degree of dynamic under the bridge coronary stenosis and the degree of proximal to the bridge atherosclerosis was detected.

Despite the fact, that no correlation between the degree of myocardial hypertrophy and the frequency of myocardial bridges, as well as the degree of under the bridge systolic stenosis of the coronary artery was determined, it should be noted that patients with significant and moderate ventricular myocardial hypertrophy were included in the study. No cases of hypertrophic cardiomyopathy were included in the research; by some authors it has a major role in increasing the pontine compressive effect.

GENERAL CONCLUSIONS

1. The anatomic variability of coronary arteries is represented by: variants of origin; high frequency of numeric variations at the level of the marginal and diagonal branches, and varieties of atypical intramural trajectory, like complete myocardial bridges, incomplete myocardial bridges, typical and atypical myocardial tunnels.

2. Proatherogenic conditions are preponderantly created in the proximal and middle segments of the anterior interventricular branch, the middle and distal portions of the right coronary artery and the prepontine portions in atypical vascular trajectories, all resulting from the local hemodynamic stress. In the intramural coronary portion, cyclic systolic compression and local hemodynamic parameters reduce under the bridge proatherogenic effects.

3. Myocardial perfusion is significantly influenced by variants of the atypical intramural trajectory of coronary arteries with a diameter over 2 mm, located in the upper and middle third of the left ventricle, especially in the middle segment of the anterior interventricular branch. The correlation between the artery and the adjacent myocardium within the atypical intramural trajectory is influenced both by structures that favour compression and by those that resist to stenosis.

4. In conventional coronary angiography, based on direct criteria (the effect of „under the bridge squeezing") and indirect criteria (under the bridge vascular aspect „in the form of trough cavity" during the cardiac systole) – can be detected approximately 5% of myocardial bridges and myocardial tunnels. Most of the detected myocardial bridges are located on the trajectory of the anterior interventricular branch and cause a moderate degree of under the bridge systolic compression.

5. Factors that may influence myocardial perfusion in systolic active myocardial bridges are: the topography of the intramural coronary segment, the size of the involved vessel and the width of the musculovascular complex, the depth of the vessel location, the association of intramural trajectory variants per vessel and per organ, the persistent deformation and narrowing of under the bridge arterial segment, narrow perivascular space, helical orientation of myocardial fibers around the artery that iare shortening and narrowing the under the bridge arterial portion during the systole.

PRACTICAL RECOMMENDATIONS

1. When evaluating the variability of the coronary arteries, it should be considered the existence of intramural trajectories: complete myocardial bridges, incomplete myocardial bridges, typical and atypical myocardial tunnels.

2. When assessing the pathogenetic aspect of the intramural trajectory of large coronary vessels, it is necessary to consider the topography of the current segment, the size of the involved vessel, the width of the musculo-vascular complex, the depth of the vessel location, the association of intramural trajectory *per* vessel and *per* organ, as well as their proximal to the bridge segments affected by atherosclerosis.

3.When assessing the effect of myocardial bridges on myocardial perfusion, it is recommended to judge on the cumulative effect of structural factors with ischemic potential, such as: thickness of the myocardial bridge, width and deformation, persistent narrowing of the vessel in the intramural part, narrow perivascular space, the orientation of the myocardium around the vessel, which shortens and narrows of the coronary artery under the bridge during the systole.

4. When assessing the possibility of the influence of the myocardial bridge over the myocardial perfusion, it is recommended to compare structural factors with ischemic potential with structures that resist to the under the bridge systolic compression: the wide perivascular space, the network rich of collagen lining the perivascular space, the collagen bundles oriented circularly to the vessel, the structural non-uniformity of the muscle band, regional doubling of the inner elastic membrane and thickening of the layer of elastic fibers in the outer tunica of the under the bridge arterial segment.

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LIST OF PUBLICATIONS AND SCIENTIFIC EVENTS
where the research results of the Ph.D. thesis
in medical sciences on the topic
„The morpho-clinical correlations of coronary arteries branches and their intramural pathway" were presented,

realized within the Department of Anatomy and Clinical Anatomy, by Mr. **Tasnic Mihail**, Doctoral School in Medical Sciences, State University of Medicine and Pharmacy „Nicolae Testemitanu"

SCIENTIFIC PUBLICATIONS

- **Articles published in journals from abroad:**
  1. **Taşnic M**., Catereniuc I., Zota Ie. Morfologia macro- şi microscopică a variantelor traiectului intramural al arterelor coronare. *Revista Româna de Anatomie funcţională şi clinică, macro- şi microscopică şi de Antropologie. Iaşi, România*. 2008; 7 (3): 334-343.
  2. **Ташник М.** Вариабельность интрамурального хода венечных артерий сердца (морфо-клинические аспекты). *Клінічна анатомія та оперативна хірургія. Чернівці*; 2009; 2: 29-35.
  3. **Ташник М.В.,** Катеренюк И.М. Морфологические особенности синдрома Bland-White-Garland. *Клінічна анатомія та оперативна хірургія. Чернівці, Украина*. 2010; 1: 49-52.
  4. **Tasnic M.,** Catereniuc I., Costru-Tasnic E. The relationship between the first layer of the myocardial bridge and the longitudinal axis of the under-bridge arterial segment. *Scripta Scientifica Medica (Varna, Bulgaria).* 2013; 45(4): 59-65.
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- **Articles published in national journals:**
  - ✓ **B-category published articles**
    6. **Taşnic M**., Catereniuc I**.,** Guzun Gh. et al. Actualități morfologice în structura punților miocardice complete. *Buletinul Academiei de Ştiinţe a Moldovei. Ştiinţe Medicale. Chişinău.* 2013; 1(37): 150-156. ISSN 1857-0011.
    7. **Taşnic M**., Catereniuc I. Some morphological aspects of myocardial bridges. *Moldovan Medical Journal*. *Chisinau*. 2021;64(2), 4: 58-64. ISSN 2537-6381.
    8. **Taşnic M**., Revenco V. Catereniuc I. Correlations of myocardial bridges with left ventricle myocardial hypertrophy and prepontin coronary atherosclerosis. *Moldovan Medical Journal*. *Chisinau*. 2021;64(5), 2: 21-26. ISSN 2537-6381.
  - ✓ **C-category published articles**
    9. **Taşnic M**., Stupac I. *Variabilitatea arcului aortei şi ramurilor lui (aspecte morfologice). Anale Ştiinţifice. USMF „Nicolae Testemiţanu". Vol. I. Probleme medico – biologice şi farmaceutice. Chişinău.* 2006; p. 48-56. ISSN 1857-1719.
    10. **Taşnic M**., Catereniuc I., Reuţchi E. Variabilitatea individuală a structurilor cordului. Anale Ştiinţifice. USMF *Nicolae Testemiţanu*. Ed. IX, vol. I. *Probleme medico-„biologice şi farmaceutice.* Chişinău. 2008; p. 27-33. ISSN 1857-1719.
    11. **Taşnic M**. Corelaţiile ramurilor arterelor coronare cu straturile peretelui cardiac. *Anale Ştiinţifice. USMF „Nicolae Testemiţanu". Vol. II. Probleme medico – biologice şi farmaceutice*. Chişinău. 2007; p. 39-45. ISSN 1857-1719.
    12. **Taşnic M**. Particularităţile de origine, ramificare şi distribuire ale ramurii intraseptale superioare din sistemul arterii coronare stângi. *Anale Ştiinţifice. USMF „Nicolae Testemiţanu". Vol. I. Probleme medico – biologice şi farmaceutice*. Chişinău. 2009; p. 86-91. ISSN 1857-1719.

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- **Articles published for scientific conferences:**
  - ✓ **international conferences from abroad**

16. **Ташник М.,** Катеренюк И. Случаи отхождения левой позвоночной артерии от дуги аорты. Актуальные проблемы морфологии. *Сборник трудов. Минск, Беларусь*, 2006: 152-153.
17. **Ташник М.** Коронарографические аспекты интрамурального хода крупных ветвей венечных артерий сердца. Сборник статей конференции «Весенние атомические чтения» посвященной памяти доцента З.А. Пашенко. *Гродно, ГрГМУ*, 2011: 47-50.
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20. **Taşnic M**., Catereniuc I., Petrovici V., Costru-Taşnic E., Catereniuc D. Variabilitatea morfologică a arterelor coronariene și ramurilor lor. *Actual issues of morphology. Materials of the International Scientific Conference dedicated to 70th year anniversary of Nicolae Testemitsanu State University of Medicine and Pharmacy. Chisinau, October, 15-16, 2015 / Probleme actuale ale morfologiei. Materialele Conferinţei Ştiinţifice Internaţionale dedicată celor 70 de ani de la fondarea Universităţii de Stat de Medicină şi Farmacie „Nicolae Testemiţanu”*. Chişinău, 15-16 octombrie 2015, p. 144-148.

- **Abstracts published for international and national scientific conferences:**

21. **Taşnic M.,** Stupac I. Congenital anomalies of the aortic arch. *Curierul Medical, Special Edition*; 2006. p. 37.
22. **Ташник М**. Редкий случай атипичной внутриорганной топографии венечной артерии. *Анатомо-хірургічні аспекти дитячої гастроентерології. Матеріали научного симпозіуму. Чернівці*. 2007; с. 78-79.
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35. **Tasnic M.,** Costru E. Microscopic features of the structures involved under complete myocardial bridges. *Матерьялы 65-й Международной научной конференции студентов и молодых ученых, посвященной 90-летию, Беллорускогo государственного медицинского университета, в двух частях. Актуальные проблемы современной медицины. Часть 2. Минск, Беларусь*; 2011. с. 467-468.
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39. **Ташник М.**, Катеренюк И. Макромикро- и микроскопические особенности иннервации передней межжелудочковой артерии при наличии мышечных мостиков. *Анатомия человека: вчера, сегодня, завтра. Материалы конференции, посв. 250-летию кафедры анатомии человека Первого МГМУ им. И.М. Сеченова, Москва*; 2014, с. 131-133.
40. Катеренюк И., **Ташник М.,** Петрович В., Катеренюк Д., Костру-Ташник Е.

Морфологические особенности извитого хода венечных артерий сердца. *Mat. XIII Конгресса МАМ, Петрозаводск, 24-27.05.2016, Морфология*; 2016, том 149, 3, с. 99.

41. **Ташник М.**, Катеренюк И., Петрович В., Костру-Ташник Е., Катеренюк Д. Сравнительная характеристика степени атеросклеротического поражения ветвей венечных артерий сердца. *Матеріали науково-практичної конференції з міжнародною участю «Актуальні питання клінічної анатомії та оперативної хірургії», присвячена 75-річчю від дня народження професора В.І. Проняєва, Чернівці, 24-26 березня 2016, Чернівці*; 2016, с. 95-97.
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43. **Tasnic M.** Anatomical features of complete myocardial bridges and its role in sudden death occurrence. *Abstract Book. MedEspera 2018, The 7th International Medical Congress for Students and Young Doctors; 2018,* p. 174-175.
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45. **Tasnic M.** Clinical and interventional key points in patients with myocardial bridges. *Abstract Book. MedEspera 2020, The 8th International Medical Congress for Students and Young Doctors; 2020*, p. 204-205.

- **Invention certificates:**
  57. Catereniuc I., **Taşnic M.,** Petrovici V., Siniţina L. Modificarea metodei de impregnare argentică spre evidenţierea elementelor neurovasculare extra- şi intraorganice. MS RM. Certificat de inovator nr. 4915 din 30.11.2010.
  58. Catereniuc I., **Taşnic M.,** Petrovici V., Siniţina L. Modificarea metodei de colorare a fibrelor elastice cu orceină. MS RM. Certificat de inovator nr. 4930 din 05.01.2011.
- **Active participation within scientific forums:**

1. **International**

  48. **Ташник М.** Случаи отхождения левой позвоночной артерии от дуги аорты. *Международная научная коференция «Актуальные проблемы морфологии» посвяшеной 85-летию БГМУ*, Минск, 23-24 ноября 2006.
  49. **Taşnic M.** Congenital anomalies of the aortic arch. *1 st International Medical Students and Young Doctors Congress "Medespera 2006",* may 2006.
  50. **Taşnic M.** Complete myocardial bridges, incomplete myocardial bridges and myocardial tunnels. *19 European Students Conference Promising Medical Scientists Willing to look beyong, Berlin, 29 september – 3 october* 2008.
  51. **Taşnic M.** The contribution to morphoclinical study of intramyocardial topography of coronary arteries. *2 nd International Medical Students and Young Doctors Congress "Medespera 2008", 14*-17 may 2008 – diplomă de gradul III.
  52. **Ташник М.** Морфологические аспекты инрамурального хода крупных ветвей венечных артерий. *Міждународна наукова конференція студентів та молодих вчених «Молодь – медицині майбутнього»,* Одесса, 23 квітня 2008 – diplomă de gradul II
  53. **Ташник М**. Миокардиальные мостики и коронарная недостаточность в морфологическом аспекте. *Міждународна наукова конференція студентів та молодих вчених «Молодь – медицині майбутнього»,* Одесса, 23 квітня 2009 – diplomă de gradul I.
  54. **Taşnic M**. The neurovascular correlation of myocardial bridges with the anterior interventricular branch. *3 rd International Medical Congress for Students and Young Doctors MedEspera.*. Chişinău, 19-21 may 2010 - diplomă de gradul II.

55. **Ташник М.,** Костру Е. Особенности иннервации предмостикового сегмента венечных артерий. *VIII-я Міжнародноя Студеніскоя науковоя конференція «Перший крок в науку».* Винница, 17-18 березня 2011 - diplomă de gradul II.
56. **Ташник М.** Сосудисто-нервно-мышечные взаимоотношения по ходу передней межжелудочковой артерии сердца. *Междун. научно-практ. конф. «Современные аспекты фундаментальной и прикладной морфологии», посв. 110-летию со дня рождения академика НАН Беларуси Д.М. Голуба.* Минск, 20-22 апреля 2011 - diplomă de gradul I.
57. **Taşnic M**. Clinical cases of transient and intermittent complete left bundle branch block. *The 4th International Medical Congress for Students and Young Doctors MedEspera2012*, Chisinau, 17-19 may 2012 - diplomă de gradul I.
58. **Taşnic M**., Catereniuc I., Guzun Gh., Bondarev A. Raportul punților miocardice cu axul longitudinal al segmentului arterial subpontin. *International Conference of Young Researchers. X edition.* Chișinău, 23 november 2012.
59. **Tasnic M.** The relationship between the first layer of the myocardial bridge and the longitudinal axis of the under-bridge arterial segment. *Jubilee symposium 50 years of the department of anatomy, histology and embryology Medical university.* Varna, 1-2 November 2012.
60. **Taşnic** M. Variabilitatea morfologică a arterelor coronariene și ramurilor lor. *Actual issues of morphology. International Scientific Conference dedicated to 70th year anniversary of Nicolae Testemitsanu State University of Medicine and Pharmacy.* Chisinau, October, 15-16, 2015
61. Cozma C., Eraslan H., **Tasnic M.** Particularities of acute myocardial infarction approach in a patient with coronary arteries anomaly. *The 7th International Medical Congress for Students and Young Doctors, MedEspera 2018. Chisinau, 3-5 May 2018.*

2. **National**

62. **Taşnic M**.; Stupac I. Variabilitatea arcului aortei şi ramurilor lui (aspecte morfologice). *Conferința Științifică Anuală a Colaboratorilor și Studenților consacrată celor 15 ani de la Proclamarea Independenței Republicii Moldova.* Republica Moldova, Chişinău, 19 octombrie 2006 - diplomă de gradul I.
63. **Taşnic M**. Corelaţiile ramurilor arterelor coronare cu straturile peretelui cardiac. *Conferința Științifică Anuală a Colaboratorilor consacrată Anului "Nicolae Testemițanu" și cu prilejul aniversării a 80 ani de la naștere* . Republica Moldova, Chişinău, 16-19 octombrie 2007 - diplomă de gradul I.
64. **Taşnic M**., Catereniuc I., Reuţchi E. Variabilitatea individuală a structurilor cordului. *Conferința Științifică Anuală a Colaboratorilor.* Republica Moldova, Chişinău, 15-17 octombrie 2008 - diplomă de gradul I.
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69. **Taşnic M**., Revenco V. Catereniuc I. Corelațiile punţilor miocardice cu hipertrofia miocardului ventriculului stâng și ateroscleroza coronariană prepontină. *Conferința științifică anuală. Cercetarea în biomedicină și sănătate: calitate, excelență și performanță.* Chișinău, 20-22 octombrie, 2021.

- **Poster presentations within international scientific forums:**

70. **Tasnic M.** Morphological aspects of myocardial bridges. *ESC Congress*. Rome, 27-31 august, 2016.

TASNIC Mihail

THE MORPHO-CLINICAL CORRELATIONS OF CORONARY ARTERIES BRANCHES AND THEIR INTRAMURAL PATHWAY

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