THE RELATIONSHIP BETWEEN THE FIRST LAYER OF THE MYOCARDIAL BRIDGE AND THE LONGITUDINAL AXIS OF THE UNDER-BRIDGE ARTERIAL SEGMENT

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ABSTRACT

Complete myocardial bridges (CMB) are myocardial bundles which cover a portion of the underepicardial coronary artery on one or more of its parts. Most frequently CMB cover the anterior interventricular branch, followed by the diagonal branches of both ventricles, first marginal branch and posterior interventricular branch.It is important to consider the association of several bridges on the same vessel or on different vessels. Microscopic picture of the under-bridge segments indicates that the term of myocardial bridge is arbitrary. Thus, while in thin myocardial bridges the direction of the myocardial fibers is similar to the basic layer, in thick bridges, especially those located on the anterior interventricular branch, myocardial fibers surround the vessel from all the parts and present a spiral orientation. Depending on the topography of the myocardial bridges, intramural vascular segment can be intersected by muscle bundles perpendicular, under an acute angle according to the longitudinal axis of the vessel or they can be oriented parallel to the vessel.According to the angle of intersection of the vessel by the muscle bundles, we could explain the different compression and strength levels of intramural vascular segment in different arterial segments.Histological study shows some morphological features, which would explain myocardial ischemia in some cases of intramural trajectory of large coronary arteries, such as deformation of the vessel, persistent vessel narrowing and narrow perivascular space.

Key words: *complete myocardial bridge, myocardial ischemia, coronary atherosclerosis, persistent arterial narrowing, intramural trajectory of large coronary arteries*

INTRODUCTION

Depending on coronary artery correlations with the heart wall, it can be described under-epicardial and intramural arteries. Some segments of the main coronary arteries can be covered by myocardial strips, the so-called myocardial bridges (1,10). For the first time myocardial bridges were described by Reyman in 1737 as an anatomical curiosity, followed by Black's findings in 1805 (7,10). Only the last decades scientific papers about the myocardial bridges involvement in the pathogenesis of ischemic sufferings of the heart in young people or children with intact coronary vessels appeared.

According to some findings (9,18) the incidence of myocardial bridges discovered during necropsies reach up to 85-86%. The analyzed publications present a lot of uncertainties and conflicting data concerning the incidence, anatomical classification, etiopathogenic pathways of cardiac ischemia induced by myocardial bridges, their correlation with age, sex, type of coronary blood supply, constitutional type, diagnostic and treatment methods of symptomatic myocardial bridges.

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There is a large amount of literature data on the active role of myocardial bridges in appearance of: angina pectoris, subpontine coronary dissection (17), ventricular tachycardia (6,14), paroxysmal atrioventricular block caused by ischemia of the conductive system (4,5). A special interest presents the publications about the involvement of thick myocardial bridges in the heart emergencies, such as myocardial infarction, spontaneous ventricular fibrillation (3,14), coronary thrombosis (2,16), sudden death caused by physical exercises in young people (12,15) and children with clean coronary vessels (8,11).

According to Raileanu C., et al. (2008), myocardial bridges are insufficiently explored clinical entities, a diagnostic and therapeutic challenge (13).

MATERIAL AND METHODS

The present study was realized on 200 formalized human hearts, adults and children of different age, performed the first 24 hours after death.

The hearts were studied by fine anatomical dissection method to determine the morphological features of intramural curse of large coronary arteries at macroscopic level.

At macro-microscopic level were studied 35 hearts stained with Schiff reagent.

Microscopical study was realized on histological sections (35 objects) stained with hematoxylin-eosin and pycrofuxin by van Gieson method.

RESULTS AND DISCUSSION

Complete myocardial bridges (CMB) are myocardial strips coverring a portion of the underepicardial coronary artery on one or more its parts. The vessel enters in the myocardium with subsequent recurrence under the enpicardium after an intramural trajectory (Fig.1A).

According to the correlation between myocardium and coronary arteries, in all variants of intramural curse of large coronary arteries, it could be described under-epicardial and intramural arterial portions or proximal to bridge arterial segment, intramural (under-bridge) and distal to bridge arterial segments.

In our study the CMB were found in 62,5% cases. The bridges were classified corresponding to the following criteria: width (wide / narrow), thickness (thin / thick), vessel involved (arterial / venous / arterial and venous), bridge myocardium origin (atrium / ventricle), histological structure (muscular / muscular and conjunctive).

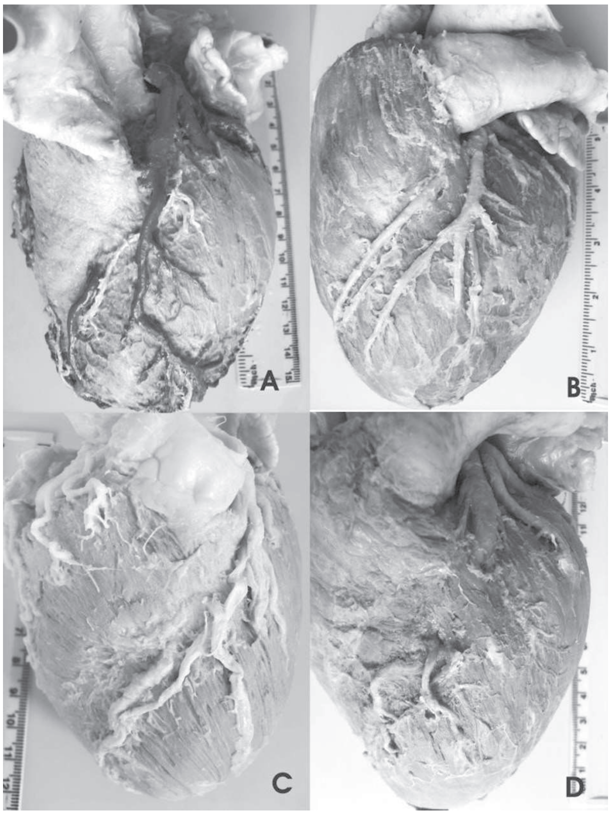

Fig. 1. Complete myocardial bridges along anterior interventricular branch

The entrance of the artery in the myocardium can be gradual, followed by progressive thickening of the bridge. In other cases the "gate" of the bridge is thickened from the start, looking like the «snare bulging muscles." (Fig.1D).

We found a few millimetres thick myocardial bridges, and up to 10mm thick CMB.

Myocardial bridges can be perforated by nerves and blood vessels of small diameter, emerging from subpontin arterial segment. Therefore complete myocardial bridges covering the anterior interventricular branch are crossed by diagonal branches from the under-bridge arterial segment of the vessel (Fig.1C,D).

Most bridges can be considered as thin ones, a few millimetres bridges, which usually cover diagonal branches and small under-epicardial branches of the left and right ventricles (Fig.3D).

Thick myocardial bridges, up to 1 cm, were detected exclusively in the middle third of anterior interventricular branch (Fig.1C,D; 2).

They were found only single cases of subpontin arterial segments localized under-endocardialy, in the proximity of left ventricular cavity. On cross section of these structures, intramural segment of anterior interventricular branch was bordered from the left ventricular cavity by a narrow muscular bundle of 1-2 mm (Fig.2).

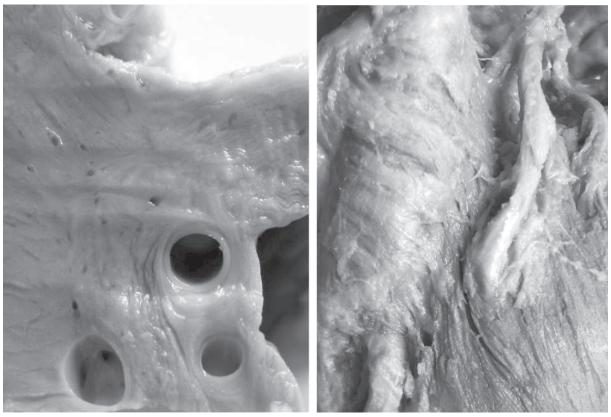

Fig. 2. Thick miocardial bridge along anterior interventricular branch, cross section (a), anterior view (b)

Myocardial bridges width' widely varies. The width of most of complete myocardial bridges was about 10-19 mm (34%) (Fig.1B), 25% - 20-29 mm, 18% - 1-9 mm and only in 4% of cases were found wide bridges, up to 70 mm, on anterior interventricular branch (Fig.1C).

Complete myocardial bridges usually are related to ventricular wall, occasionally were found loop-like myocardial structures with the origin and insertion of the fibbers in the myocardium of the atrium. Most of these structures surround the circumflex branches located in the coronary groove.

Topographically, most bridges are located on the main branches of the left coronary artery.

The most frequently CMB cover anterior interventricular branch (Fig.1A), followed by the diagonal branches of ventricles (Fig.3D), first marginal branch (Fig.3A) and posterior interventricular branch (Fig.3C).

Only in one case a complete myocardial bridge was found on the main trunk of the right coronary artery (Fig. 3B) and its branches.

The widest (up to 70 mm) and thickest (up to 8-10mm) complete myocardial bridge was found on the anterior interventricular branch.

The study shows that more frequently CMB cover distal portions of the proximal third and of the upper and middle parts of the middle third of the anterior interventricular branch (52% of cases with CMB located on anterior interventricular branch) (Fig.2A,C,F). Less frequently the CMB cover only the proximal (24%) or middle third (20%) of the named vessel (Fig.1B).

Only in 4% of cases were detected subtotal complete myocardial bridges, which covered more than 75% of the length of anterior interventricular branch (Fig.1C,D).

In the cases of myocardial bridges which cover the upper third and the proximal part of the middle third of the anterior interventricular branch at the origin of pulmonary trunk, usually, the vessel enters sharply under the bridge, forming a thick myocardial gate looking like a muscular loop (Fig.1D). CMB located more distal are characterized by gradually "sinking" in the myocardium, forming primary incomplete myocardial bridges, followed by complete myocardial bridge.

In the cases of complete myocardial bridges which cover the first marginal branch of the left ventricle, muscle bundles length varies between 20-40mm and are localized the most frequently in the middle third of the vessel (Fig.3A). In unique cases were detected wide myocardial bridges located on the first left ventricular marginal branch.

Another example of frequent location of CMB is diagonal arteries of the left ventricle. These bridges can be considered isolated entities or may be a continuation of the muscle bridge that covers the anterior interventricular branch.

It is important to consider the association of several bridges on the same vessel or on different vessels.

In 34% of studied hearts (48% of the hearts presented CMB), there were more than one CMB per one heart. The most common association was between the bridge on the anterior interventricular

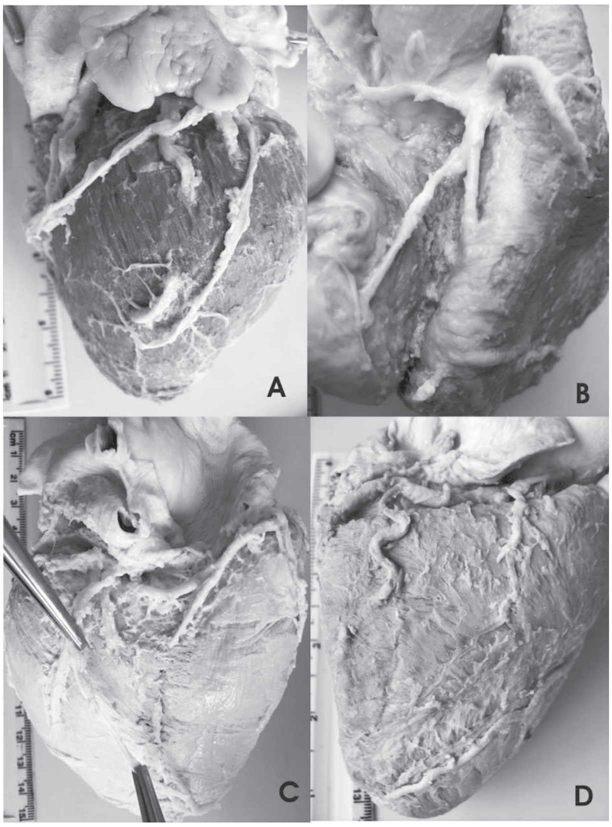

Fig. 3. Complete myocardial bridges along first marginal branch (a), right coronary artery (b), posterior interventricular branch (c), anterior right ventricular branch (d)

branch and the first marginal branch. Such variants were detected in 21% cases.

The maximum number of CMB detected per organ was seven structures. The maximal number of myocardial bridges detected on one vessel was 3 structures.

Studding the perivascular nerves of the hearts at an early age, using selective staining with Schiff's reagent, we discovered that big nerve trunks were involved with the vessel under the bridge (Fig.4A,B). Such trajectory could affect the normal transmission through these structures due to permanent systolic compression of the nerves.

Macro-microscopic and microscopic study revealed a persistent arterial deformation (Fig.4B,C; Fig.6C,D). Consecutively, the vessel had the shape of sand clock or of a saw (Fig.4B). These observations were confirmed during microscopic study of CMB which cover anterior interventricular branch (Fig.6C). The persistent deformation of the under-bridge part of the vessel could affect blood flow rheological features in proximal to bridge, under-bridge and distal to bridge arterial segments.

Microscopic picture of the under-bridge segment indicates that the term of myocardial bridge is arbitrary. Thus, while in thin myocardial bridges the direction of the myocardial fibers is similar to the first myocardial layer, in thick bridges, especially those located on the anterior interventricular branch, myocardial fibers surround the vessel from all the parts and have helicoidally orientation, forming a myocardial tunnel around the vessel (Fig.5). Helix-like orientation of myocardium around the vessel is able not only to compress the vessel during the systole, but also to shorten the artery. Therefore, the main difference between this vessel trajectory from the real myocardial tunnel is the possibility of the vessel to return under the epicardium in case of myocardial bridge.

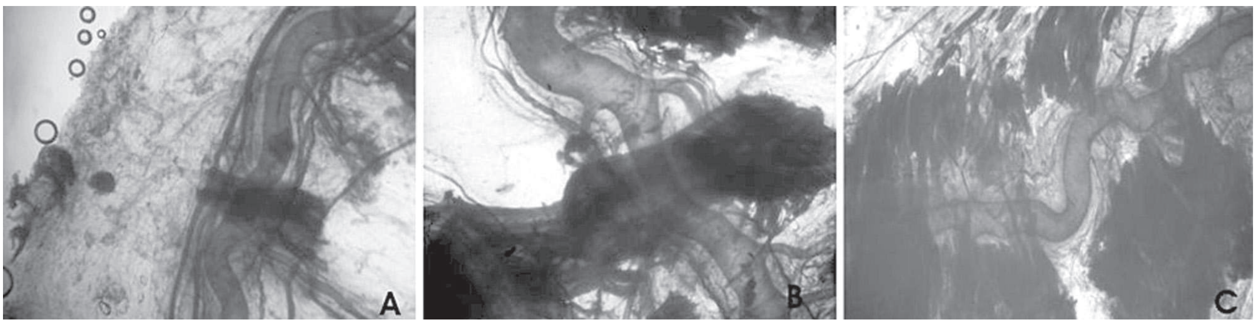

Fig. 4. Big nerve trunks involved with the vessel under the bridge (a.b) and persistent arterial deformation under the miocardyal bridge (c), stained with Schiff reagent

Depending on the topography of the myocardial bridge, the intramural vascular segment can be intersected by muscle bundles perpendicular, under an acute angle according to the longitudinal axis of the vessel or they can be oriented parallel to the vessel.

According to the angle of intersection of the vessel by the muscle bundles, we could explain the different compression and strength levels of intramural vascular segment in different arterial segments.

The anterior interventricular branch (AIVB), which intramural segment is at the boundary between the upper and middle thirds of the left ventricle, usually is covered by a CMB where muscle fibers will form an acute angle with the vessel.

In the middle and distal thirds, the intramural arterial segment is crossed by a band of myocardium perpendicular to the artery. At the apex of the heart interventricular branch will be covered by the myocardial bridge which will be parallel to the vessel.

The diagonal branches, in the proximal and middle thirds, are intersected under an acute or right angle by the bridge. In the lower third, the vessel is crossed by parallel fibers to the artery. Left ventricle marginal branches, which fall under the bridge in the upper third of the left ventricle, will pass between muscle bundles. Thus fibers are oriented parallel to the vessel. The myocardial bridges, covering the middle or lower third of this vessel, cross it under an acute angle.

Fig. 5. Helix-like orientation of myocardium around the vessel, under the bridge. Cross section of the under-bridge segment of the anterior interventricular branch

Usually, in case of presence of CMB on the posterior interventricular branch, its fibers are oriented strictly perpendicularly to the vessel.

A particular situation characterises the myocardial bridges covering the right coronary artery, in which case the fibers always intersect the vessel under a right angle. On the other hand, anterior branches of the right ventricle, emerging from the right coronary artery in its proximal third, will undergo the bridge oriented parallel to the vessel.

It is very important to know the microscopic relationship between the myocardium and the under-bridge vessel which helps us to understand the concept of active and inactive myocardial bridges. Thus, to determine the degree of systolic compression of the vessel during heart systole it is not only important to know the bridge thickness, width, histological composition, but also the bridge fibers' orientation to the longitudinal axis of the under-bridge vascular segment. It follows that arterial branches entering under a bridge parallel to the vessel myocardial fibers may be not compared to those portions of the coronary vessels crossed by the bridge obliquely or perpendicularily. These observations may explain why most active complete myocardial bridges are located at the boundary between the upper and middle thirds of the anterior interventricular branch.

Musculo-vascular space (peri-vascular) under the bridge almost entirely is complemented by a network of conjunctive elements, in which the collagen fibbers are oriented chaotically, being a direct continuation of the vessel adventitia. At the border with the bridge muscular walls, the fiber orientation can be arranged around the vessel, grouped in bundles and infiltrating the adjacent myocardium (Fig. 6A,B).

We believe that during the heart systole these fibers, having circular orientation to the vessel (Fig.6B), may play an anti-compression role and give resistance to systolic force of vessel stenosis.

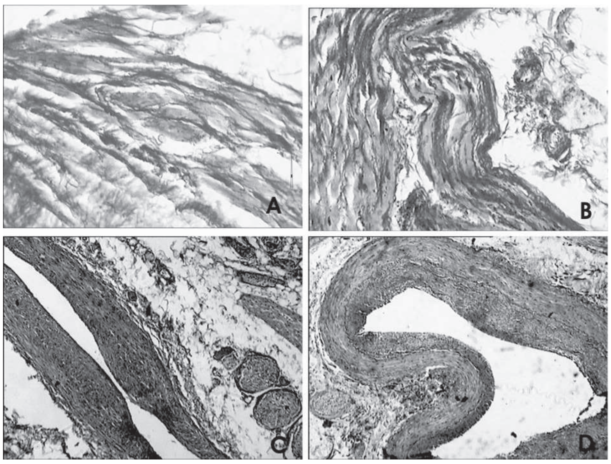

Fig. 6. Microscopic relationship between the myocardium and the under-bridge vessel, anterior interventricular branch. Stained with hematoxylin-eosin and pycrofuxin by van Gieson method

CONCLUSION

1. The majority of the heart vessels have intramural course. Only cases of intramural course of large coronary arteries, localized usually under the epicardium, are interesting from pathological point of view. Analysis of the variants of intramural pathway should be done as a whole, per vessel and per organ, as their frequent association could have bad aggravating consequences.
2. Histological study shows some morphological features what could play an important role in heart ischemic sufferings; these features are the deformation and narrowing of the vessel under the bridge.
3. To determine the degree of systolic compression of the vessel during heart systole it is not only important to know the topography of the bridge, the diameter of the involved vessel, the deepness of the under bridge vessel, the association of more myocardial bridges on one vessel or on deferent vessels, the presence of atherosclerosis in the proximal to bridge segment, the thickness, width and muscle-conjunctive composition of the CMB, but also the muscle's fibers orientation to the under-bridge blood vessel. The vascular branches surrounded by parallel myocardium could be less compressed than those portions crossed obliquely or perpendicularly by CMB.

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