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Myocardial bridges in the human heart: morphological aspects

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The structures made of myocardium running most often above the coronary arteries are called the muscle bridges. However there is a large number of descriptions of that phenomenon, the data are not homogenous. Some papers affirm the occurrence of the clinical implications of their existence. The studied material contained 100 adult human hearts, both sexes, 21 to 76 years of age, preserved in formalin-ethanol solution. Standard anatomical methods were used in analysis with the help of a binocular magnifying glass. The presence of the bridges was confirmed in 41% of the researched material, most frequently above the anterior interventricular branch. The length of the bridges varies in the range of 2.3–42.8 mm, thickness 1.0–3.8 mm, angle between long axis of muscle fibres and long axis of the crossed vessel from 5° to 90°.

key words: human heart, coronary arteries, myocardial bridge

INTRODUCTION

Muscle bridges (MB) are structures consisting of muscle tissue of the heart running above the coronary arteries and their branches. However the MB are most often observed above large arteries, and there are also reports confirming their existence above some heart veins [1].

The first description of MB dates from 1737 — Reymann [12] observed that segments of the left coronary artery can be covered with a thin layer of heart muscle fibres. In 1968 Polacek and Zechmeister [10] researched a dozen mammal species, respectively dividing them into 3 groups using the existence or lack of MB as the criteria: type A, within which the arteries run intramuscularly (rat, rabbit), type B — the vessels running usually epicardially, but in some cases the MB could occur (human, monkey, dog), and type C within which MB does not occur (horse, cow). The first in vivo report ascertaining the presence of MB derives from 1960 — Portsmann and Iwig [11] during coronarography stated the periodical closing of the anterior interventricular branch (RIA) segment during systole.

However there exists a relatively large number of MB descriptions and researchers do not present a uniform attitude towards the phenomenon. The frequency of MB, their location and morphology arouse the most controversies. Most scientists agree that the existence of MB can significantly modulate the haemodynamic phenomena in coronary vessels. There are also reports suggesting that the bridges could influence the dynamics of sclerotic changes and cause a deficit of myocardium blood supply during high heart rate [7,8]. The diversity of literature data and of significant clinical implications of MB presence, induce the need of detailed analysis of those structures.

MATERIAL AND METHODS

The research was carried out on 100 human hearts, adult, both sexes (59 M, 41 F) 21–76 years of age, in which no macroscopic developmental failures were

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found. The hearts were preserved in formalin-ethanol solution. With the classic anatomic research methods the location and chosen morphological features (length, thickness, direction of muscular fibres run) were estimated. The coronary arteries were analysed in consecutive, 3 mm each cross-sections — from the branching of the aortic bulb to the level at which the external diameter of the vessel was ca 1 mm. The structures were described using a binocular magnifying glass (magnification 4–8×).

RESULTS

The presence of MB was confirmed in 41 hearts (41%), more often in male hearts (M 25, F 16). Coherently there were observed 50 MB loated mainly above the anterior interventricular branch of the left coronary artery (RIA) — 33% of examined hearts (Fig. 1), sporadically above other vessels: diagonal branch of left coronary artery (Rd) — 5%, posterior interventricular branch of right coronary artery (Rip) — 4%, left marginal branch (Rms) — 3% (Fig. 2), right marginal branch (Rmd) — 1%. 3 configurations were distinguished: 1) one MB in the heart; 2) two MB in the heart, both above the same vessel; 3) two MB in the heart above different vessels. The first, the most common, relates to the hearts with bridges above RIA (24% of the material), more rarely above Rd and Rms — 3% each, above Rip and Rmd 1% each. The second type of configuration contains hearts with MB only above RIA — 4%. In the third type 5 cases were classified: 3 hearts in which one MB was observed above both RIA and Rip, 2 hearts where one bridge was distinguished above each RIA and Rd.

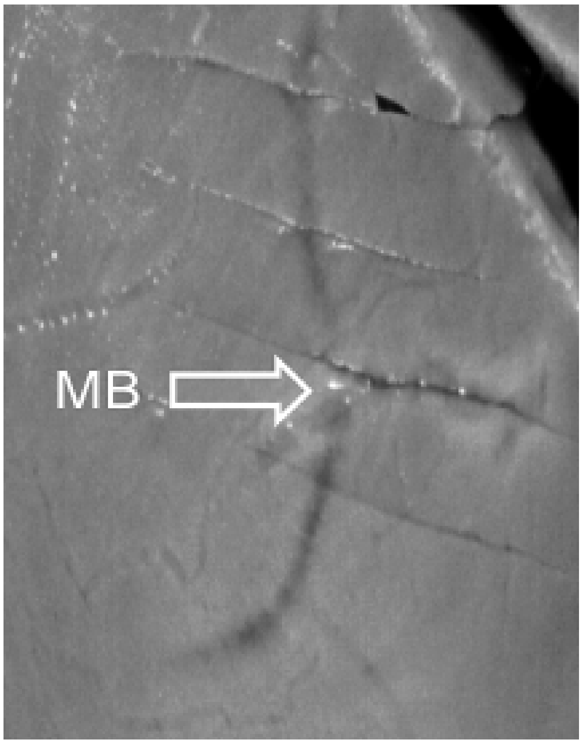

Figure 2. MB above Rms. External view (M, 45-year old).

On the basis of the research the most frequent location of MB was established — usually it was the middle 1/3rd of the vessel. The length of muscle bridges varied in a wide range between 2.3 and 42.8 mm. The shorter structures — up to 20 mm – occur more often. The significant fact is that the longest MB were situated above RIA, that is the place of their most frequent presence. The shortest bridge was noted

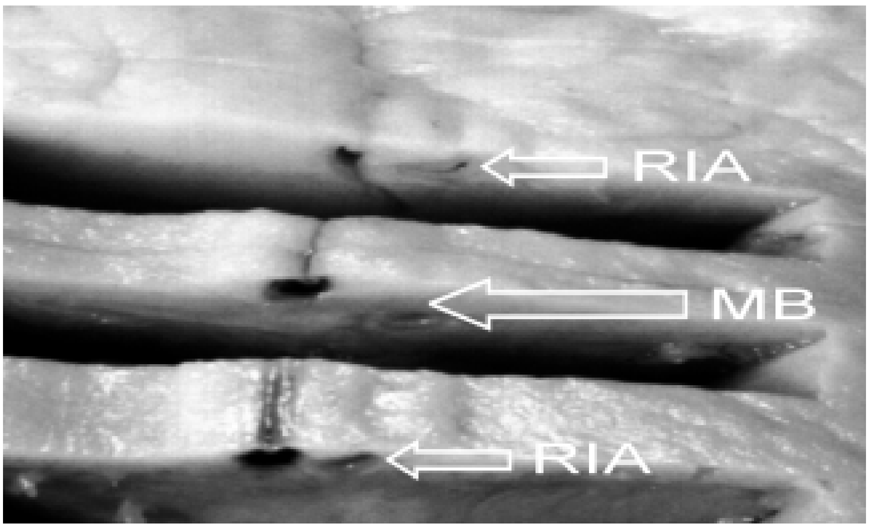

Figure 1. MB above RIA. Cross-section (M, 56-year old).

above Rms. The details are presented in Table 1. The analysis of MB thickness revealed that the thickest structures are combined with RIA. The thin MB were observed above Rms — 1.0 mm (Table 2). No significant correlations between length, thickness of MB and sex or age were observed. The research also involved evaluation of the direction in which the muscle fibres creating the bridge ran. The angle between the long axis of bridge muscle fibres and the long axis of the bridged vessel was also estimated. It so happens that most of the results in the case of RIA and Rip are contained between 80°–90°. Bridges above Rd, Rms and Rmd crossed the vessels with angles from 5° (Rmd) to 50° (Rd) (Table 3).

Table 1. Length of myocardial bridges

Vessel	Length [mm]	Average length [mm]
RIA	3.6–42.8	25.7
Rip	4.0–20.6	15.5
Rd	5.3–20.1	13.4
Rms	2.3–17.3	12.7
Rmd	3.3	3.3

Table 2. Thickness of myocardial bridges

Vessel	Thickness [mm]	Average thickness [mm]
RIA	1.2–3.8	1.9
Rip	1.6–3.1	1.7
Rd	1.5–2.0	1.7
Rms	1.0–1.9	1.2
Rmd	1.5	1.5

Table 3. The number of MB crossing given vessel at the nominated angle

	90°	80°	60°	50°	40°	30°	20°	10°	5°
RIA	26	6	3	1	–	–	–	–	–
Rip	2	1	1	–	–	–	–	–	–
Rd	–	–	–	1	2	3	–	–	–
Rms	–	–	–	–	–	–	2	1	–
Rmd	–	–	–	–	–	–	–	–	1

DISCUSSION

Muscle bridges are relatively often observed in anatomical studies [1], less frequently during coronarography [1,11]. As the morphologic analysis is the most sensitive, the in vivo estimation is not so accurate. Only angiographic examination allows for the visualisation of the bridge in vivo — however the process can be influenced by many unspecific factors. The disclosure of the bridge in coronarographic image depends on its thickness, length and orientation of muscle fibres, presence of other tissues within the bridge structure and also blood pressure in the vessel. There also exists a wide range of diagnostic methods used in indirect estimation of MB existence (ECG, biochemic and radioisotopic tests) [1,6]. Nevertheless studies using these techniques were conducted on too small group of patients to obtain statistically significant results.

Although the phenomenon of muscle bridges was the subject of numerous research projects, their conclusions are not homogeneous. The first description of MB dates back to the 12th century [12]. Since that time there have been some references concerning the segmental, intramuscular run of coronary arteries, but just at the beginning of the 20th century the problem of MB increased in importance. The majority of authors agree that MB most frequently emerge above RIA [1,2], as our study confirmed. The recurrence of MB brings the most controversies — in the anatomopathologic study, according to the scientific papers, they are found in 5–86%. Geringer [5] was one of the first to precisely analyse MB under macro- and microscopic aspect, unfortunately limiting his study only to RIA. He described the presence of MB in 23 hearts out of 100 observed. Edwards et al. [3] in the material of 276 hearts stated the bridges only in 15 cases, while Lee et al. [9] in 63 cases out of 108 hearts. According to Polacek and Zechmeister [10], such large differences are the result of inadequate precision of autopsy. In his experiment, he analysed a few dozen hearts, in 6% of which during common anatomopathologic examination the bridges above RIA were observed, while in the same material Polacek and Zechmeister [10] revealed MB in 60%.

According to different authors the length of bridges varies in a wide range. Geringer [5] did not find bridges shorter than 5 mm — in our study we found shorter structures above RIA — to 3.6 mm. In a few cases Geringer [5] observed that RIA, after a short run, divides into two branches of similar diameter, where one of them is covered by MB in its distant segment — such a phenomenon did not occur in our study. Such a diversity gives an excellent opportunity to examine the influence of the bridge on sclerotic changes development [5]. Nevertheless Geringer [5] did not describe neither double nor triple MB, the majority of researchers confirm the possibility of few bridges occurring over one or different vessels. In the analysis carried out we stated two bridges above RIA in 4 hearts. Also in 4 cases, we noted the presence of 2 bridges above 2 vessels. Ferreira et al. [4] in their research observed triple bridges — concerning various vessels — in 5 hearts, while Baptista and DiDio [2] just double ones and only above RIA — in 6 cases. The results of analysis concerning the direction in which muscle fibres run delivered us data similar to those of Baptista and DiDio [2]. In their material the angle between the long axis of vessel and bridge muscle fibres oscillated between 1 and 90 degrees. The most perpendicular run of MB occurred above RIA and Rip, while the most parallel, above Rms [2].

In the majority of descriptions the most common location of bridges is above RIA, less often above Rip, Rd, Rms and Rmd [1,2]. Usually MB occur above the middle 1/3rd of vessel length [1,5,9].

The ultrastructural analysis seems to be the next stage of muscle bridges examination. Unfortunately, the problem of bridges classification on the basis of morphologic criteria is still an opened question. Geringer [5] separated 2 MB types: the intramuscular profound run, where RIA was covered by the muscular tissue deriving from the anterior interventricular sulcus, and intramuscular superficial run — in that case RIA was covered by a thin layer of muscle fibres beginning in the *trigonum fibrosum* and running above the artery towards the apex of the heart. Ferreira et al. [4] classified both the above-mentioned variations as superficial, while the artery running deeply in the interventricular septum muscle was treated as profound variety.

Considering the fact that muscle bridges are suspected of having significant influence on haemodynamic phenomena in coronary arteries, those structures are recurrently the subject of clinical discussions. Appropriately thick and long MB with coexistence of fast heart rate can cause a deficit in the blood supply of the bridged artery blood supply region. The phenomenon is a consequence of little retarding in decreasing the compression of the vessel by the bridge during the diastole and could be a reason for sudden cardiac death of young people [7]. Numerous studies confirm the fact of atherosclerosis development protection in the vessel in its distal segment from the bridge. Unfortunately the negative results of MB existence are also observed. The escalation of sclerotic changes in the segment proximal to the bridge is affirmed. The degree of advancement within the intima of the vessel seems to be a function of bridge morphologic features — larger thickness, length and right angle of crossing are combined with accelerated degradation of endothelium [5,8].

Muscle bridges are still an opened issue. The discussion whether it is a pathology or a variation of physiology is still ongoing. It is known that their existence is congenital. The researches carried out on foetuses confirmed their development in the embryonal period and that they can coexist with some developmental anomalies [1].

The analysis of the phenomena on the ultrastructural level will be subject of our future research projects.

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