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MORPHOLOGY OF MYOCARDIAL BRIDGES

PHD THESIS SUMMARY

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LIST OF PUBLICATIONS

1. Niţu R., Bordei P., Ispas V. Miocardial bridges in the right coronary artery. Revista Română de Anatomie funcțională și clinică, macro- și microscopică și de Antropologie, Vol. XVIII, Nr. 2, 2019, pag. 85-89
2. Niţu R., Bordei P., Baz R., Ispas V. Morphological features on myocardial bridges at the anterior interventricular artery. ARS Medica Tomitana, 2018; 3(24), pag. 164-174; doi: 10.2478/arsm-2018-0030
3. Niţu R., Iliescu D.M., Ispas V., Baz R., Bordei P. Originea şi modul de terminare al arterei circumflexe a chordului. Vol. rez. Congresul Naţional de Anatomie Galaţi, 19-21 mai 2016, pag. 166
4. Niţu R., Bordei P., Ionescu C., Ispas V. Morphological characteristics of myocardial bridges diagnosed by ct coronarography, excepting the anterior interventricular artery. Revista Română de Anatomie funcțională și clinică, macro- și microscopică și de Antropologie, Vol. XIX, Nr. 2, 2020, pag. 78-85

Cuprins

INTRODUCTION

The muscle bridge (MB) is a hotly debated topic in the specialty literature, as evidenced by the large number of works on the topic, either through various forms of printing (specialized treatises or articles published in well-known medical journals, or through lectures delivered at organized scientific events in different parts of the world.

The coronary arteries and their major branches usually run on the surface of the heart. Sometimes the coronary arteries, or their branches, may have an intramiocardial trajectory, and the cardiac muscle fibers above the intramural segment of an epicardial coronary artery are called ***the myocardial bridge*** (MB) and the artery with the myocardial pathway is called ***the tunneling artery***.

There is controversy regarding the morphological features, diagnosis, pathophysiology, clinical relevance, and optimal therapy in symptomatic patients with MB, as antianginal drugs and surgical techniques have not been systematically tested [Ernst A].

Frequently, without clinical consequences, the presence of a significant hemodynamic MB (HSMB), characterized by some particular morphological properties (location, number, width, length, angulation, position) or association with early age and hypertrophic cardiomyopathy, can cause a wide range of heart dysfunctions.

Currently, the mechanisms by which MB induces clinical symptoms are not well known. In addition, methods for identifying and treating MB have not been perfectly established [Smith SC, Angelini P, Bourassa MG].

The clinical significance of myocardial bridges is still debatable, with debates regarding symptomatic myocardial bridges and asymptomatic myocardial bridges. Some authors [Bourassa, Kramer JR, Juillère Y] consider MB to be asymptomatic, others [Visscher DW, Vidal V, Bezera AJ, Kuhn FE, Baptists CAC] consider that MB may be a contributing factor to the development of heart complications (myocardial ischemia, circulatory disorders, angina pectoris, myocardial infarction, sudden cardiac death, systolic

compression) which, if not completed by death, require surgery. There are also authors who claim that MB provides a "protective effect" for atherosclerosis inside the coronary artery [Ishii F, Laifer LI, Kosinski A].

When performing autopsy, [Morales AR] found myocardial lesions that were indicative of ischemia in the hearts with MB. Given the association between MCH and MB, it has been suggested that in patients with MCH the presence of MB may be an additional risk factor for life-threatening death, which may result in sudden death during exercise.

[Angelini P, Hiroki T, Yassue H, Ong P] say that although most cases of angiographic systolic narrowing do correspond to anatomical MB, systolic compression can occasionally be caused by other mechanisms, such as pericardial fibrosis, tumors, or foreign bodies. In clinical practice, it has become common to use the term "myocardial bridge" to describe a restriction of angiographic entities, which causes systolic narrowing of a coronary artery. However, the use of the term is limited, in angiography its usage referring to the description of a segment of the subepicardial coronary artery that shows systolic narrowing to any degree under basal or experimental conditions. This definition would exclude septal perforators.

"***Mural Coronary***" was the term used by [Geirenger E] in his article, which was the first to be devoted entirely to this subject. This definition implies that the coronary artery returns to the epicardium, distal to the MB segment. MB "in vivo" are recognized primarily due to the effect of "systolic narrowing", an aspect highlighted on coronary angiography. Autopsy studies have not yet been fully performed to demonstrate the correlation between angiographic systolic narrowing and MB, and surgical results are often inconclusive.

Acchording to [Thej MJ], it is given several names: "***intramural coronary artery***", "***mural coronaryartery***", "***coronary artery overbridging***", "***myocardial loop***" and "***myocardial bridge***".

PURPOSE OF THE PAPER

Despite the fact that the specialty literature, especially medical journals, is rich in information on MB (frequently presented clinical cases), there is still a systematization of them that includes the whole picture of morphological characteristics, which led me to choose as topic of the doctoral thesis morphology of myocardial bridges. Because such a subject is completely missing in Dobrogea, we have decided to pursue a purely morphological study on MB in Dobrogea, as there has certainly been no such study so far, at least not in Romania.

The study will be performed by means of several study methods: dissection on formalized human chords, plastic injection followed by dissection and especially will be performed on angioCT. In all cases, the MB position will be specified, noting the location of the MB on the coronary artery (anterior interventricular artery, circumflex artery, left marginal artery, posterior interventricular artery, trunk of the right coronary artery above the posterior interventricular artery and the level of MB localization on the proximal, middle coronary branch, and distal.

Findings will be made based on gender. The characteristics of MB will be mentioned: length and thickness, and CT angiographies will specify the degree of systolic compression of the arterial segment at MB level (and possibly in diastole) and the arterial caliber at MB level in systole and diastole. The arterial caliber will be specified on the tunneling arterial branch and at proximal and distal level MB.

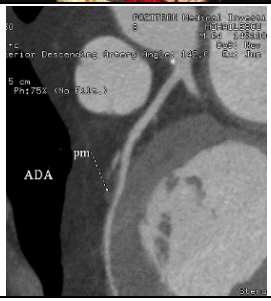
The results obtained will be supported by a conclusive number of personal images and exemplified by graphs and tables.

ABBREVIATIONS

- ✓ MB: myocardial bridge;
- ✓ HCM: hypertrophic cardiomyopathy;
- ✓ CT: computed tomography;
- ✓ CTCA: computed tomographic angiography;
- ✓ IVUS: intravascular ultrasound;
- ✓ MDCT: multidetector computed tomography;
- ✓ CAD: coronary heart disease;
- ✓ ICD: intracoronary Doppler ultrasound;
- ✓ LAD: anterior interventricular artery;
- ✓ RAD: posterior interventricular artery;
- ✓ RCA: right coronary artery;
- ✓ LCA: left coronary artery;
- ✓ CXA; circumflex artery;
- ✓ CAG: coronary angiography;
- ✓ CA: coronary angiography;
- ✓ MSCT: multislice computer tomography;
- ✓ RMN: magnetic resonance imaging;
- ✓ CT: computer tomograph;
- ✓ COT: optical coherence tomography;
- ✓ VV: vasa vasorum.

METHODS AND WORKING MATERIAL

TABLE NR. 1 - WORKING METHODS USED FOR THE MB STUDY

NR.	METHOD	NUMBER OF CASES	PHOTO
1.	Dissection	37	
2.	Plastic injection	26	
3.	CT angiographies	284	
	Total of cases	347	

63 human chords were examined, of which 37 formalized chords processed by dissection and 26 fresh chords on which plastic injections were made, followed by dissection.

For the injection of plastic mass, which was performed on fresh organs, we used Technovit 7143, of German production, a self-curing resin based on methyl methacrylate in the form of powder and liquid. After dissection, the chords were autoclaved, which gave them great stability and increased resistance to mechanical stress. In the hearts that presented MB, the location (arterial branch and MB level on the respective vessel and its distance from the coronary ostium), MB length were specified. The diameters of the tunneling vessel were made at three levels: at the origin of the artery, proximal to the MB and distal to the MB.

CT angiographies came from the Imaging Center that serves the Emergency Clinical Hospital "The Apostle Saint Andrew" in Constanta, being performed on a computed tomography GE LightSpeed VCT64 Slice CT, studying only angiographies that showed no pathological signs (except MB), our study representing basic medical scientific research, which does not require a referral diagnosis for angiographers. We consulted 2868 angioCTs, finding a number of 284 CTs with MB.

The angiography study was performed acchording to sex, rechording: sex and age of the subject, location of MB, which described the number, length, thickness, caliber of the artery at the bridge, as well as its cranial and caudal (systole and diastole), all in mm, as well as the area (area) MB, in mm2.

PERSONAL RESULTS

MORPHOLOGY OF MYOCARDIAL BRIDGES DISCOVERED BY DISSECTION

Out of the dissected cases, MB were discovered on a number of 22 chords, (10 chords being formalized and 12 chords being injected with plastic mass), on the 22 chords 36 MB were discovered, of which 16 MB on formalized chords and 20 MB on plastic-injected chords.

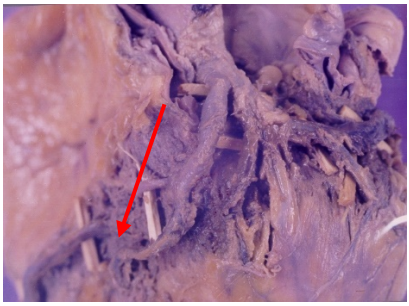


Fig. 9. MB In the lower part of the middle 1/3 of the LAD artery; length: 18 mm; origin distance: 52 mm; aortic distance: 63 mm (formalized heart).

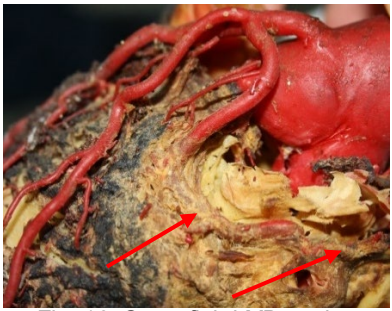
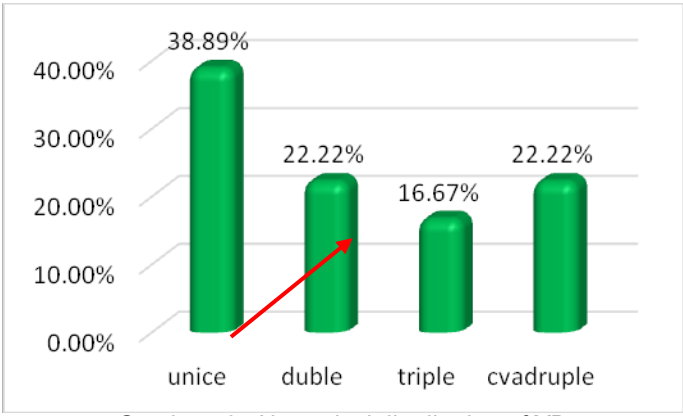


Fig. 10. Superficial MB on the circumflex artery in the coronary groove: the first, larger, on the left side of the heart, has a length of 43 mm, being at a distance of 52 mm from the origin of the artery in the LCA; the second one, near the IVP ditch, has a length of 28 mm, being at a distance of 68 mm from the origin of the LCA artery and 16 mm from the first MB (injected heart); left coronary dominance.

The distribution of the ***22 cases*** with MB was as follows:

- ***single***: 14 cases (63.64% of cases)
- ***double***: 4 cases (18.18% of cases)
- ***triple***: 2 cases (9.09% of cases) and
- ***quadruple***: 2 cases (9.09% of cases) cases).

Numerically, ***the 36 MB*** are distributed as follows: ***single***: 14 MB (38.89% of cases), ***double***: 8 MB (22.22% of cases), ***triple***: 6 MB (16.67% of cases) and ***quadruple*** : 8 MB (22.22% of cases.



Graph nr. 3 - Numerical distribution of MB

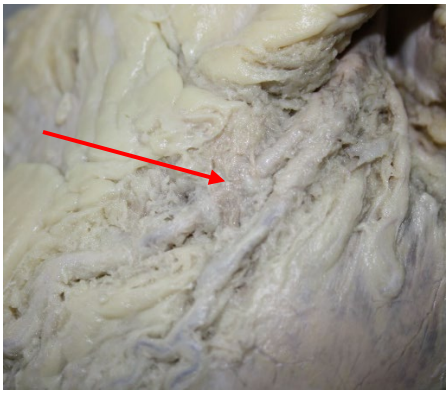


Fig. 11. Single MB, superficial at the level of 1/3 medium VAT; MB length: 7 mm; distance to VAT origin from LCA: 36 mm; VAT diameter: originally - 8 mm; above MB: 4 mm; sub MB: 3 mm; (formalized chord).

LOCATION OF MB AT THE LEVEL OF CORONARY ARTERIES AND THEIR BRANCHES

At the level of LCA we found a number of 28 MB (77.78% of cases), and at the level of RCA we found only 8 MB (22.22% of cases).
Being too short, at the level of the LCA trunk we did not encounter any case of MB, these being located at the level of the arteries LAD, Cx, left margin, left diagonal and right anterior ventricular branch.
At the VAT level we found 16 cases of MB (57.14% of the MB from the LCA level and 44.44% of the total MB).

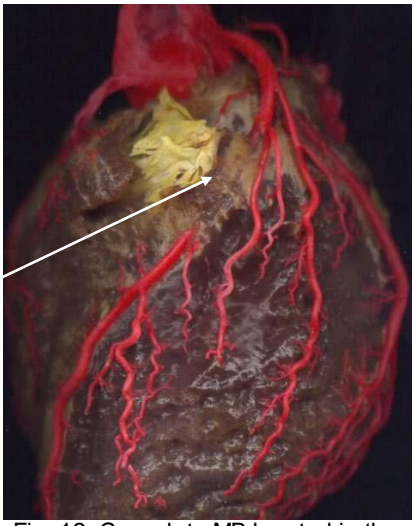


Fig. 12. Complete MB located in the upper 1/3 of the LAD artery; length: 42 mm; distance from the origin of the LCA artery: 23 mm; distance from the aorta: 41 mm (injected heart).

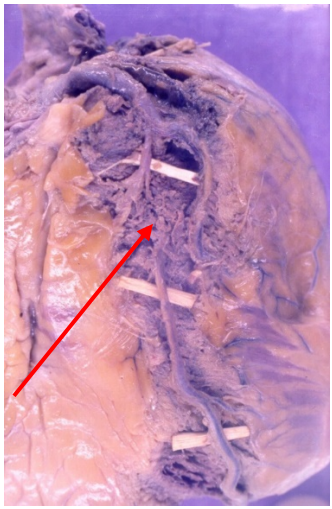


Fig. 13. Deep MB present at the middle 1/3 of the LAD artery; depth: 2.3 mm; length: 22 (formalized chord).

In the case of injected chords, the coexistence of MB at the LAD level with other MB, we found in one case on double MB together with MB on the left marginal artery and in the case of quadruple MB together with MB on the right coronary arteries,

circumflex and of the right anterior ventricular branch originating from VAT.

At the VAT level, the MB was single in 15 cases (93.75% of the MB at the VAT level), in a single case being double, (6.25% of the MB at the VAT level).

MB at the VAT level were located in 3 cases (18.75% of the MB at the VAT level), in 1/3 upper, respectively 1/3 lower of the VAT, in 10 cases (62.5% of the MB at the VAT level). VAT level), being located in the middle 1/3 of the artery.

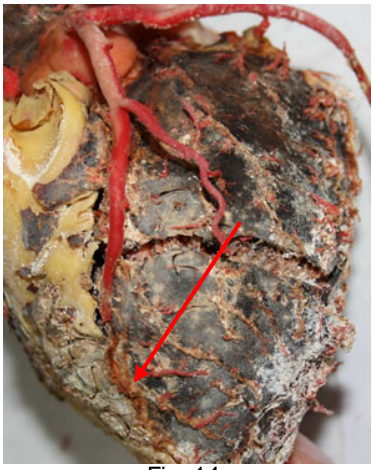


Fig. 14.
Incomplete MB in the lower 1/3 of VAT; length: 21 mm; distance from the origin of the LAD artery: 74 mm (injected chord).

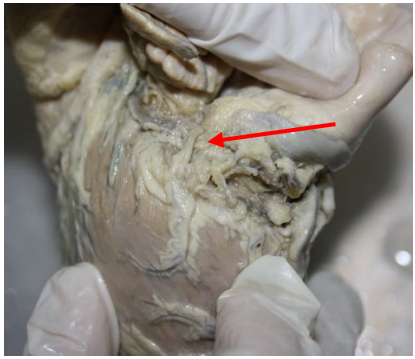


Fig. 15. Single superficial MB at the circumflex artery in the posterior coronary groove; MB length: 3 mm; distance from the origin of the circumflex artery: 21 mm (approximately in the middle of the artery); circumflex artery diameter: originally - 5 mm; above MB - 4 mm; below MB - 4 mm (formalized chord).

At the level of the circumflex artery we found 8 MB (22.22% of the total MB).

At the level of the left marginal artery we found 2 MB (5.56% of the total MB and 10% of MB on the injected chords), both cases on the injected chords, the marginal arteries having their origin, one in the aorta and the other in LAD.

Fig. 16. Superficial MB on the circumflex artery ending on the left side of the heart, near the anterior face (injected heart).

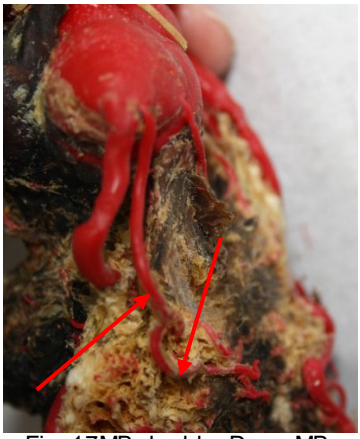


Fig. 17MB double. Deep MB, complete at the middle 1/3 of the LAD and incomplete MB on the left marginal artery, originating in the aorta (third coronary artery).

Two MB (5.56% of total MB and 10% of MB on injected chords) were ***located on the right anterior ventricular arteries***, only on the injected chords, the arteries originating one in the upper part of the LAD and the other in the RCA, at the level anterior coronary groove.

On the left diagonal artery we found a single MB (2.28% of the total MB) on the formalized chords (6.25% of the total MB on the formalized chords), the diagonal artery originating in VAT.

At the level of the RCA trunk we found 7 MB (19.44% of the total MB discovered by dissection), 2 MB being at the level of formalized chords (25% of the MB located at the RCA level and 5.56% of the total MB), being located at the level of the posterior interventricular groove and 5 MB at the level of the injected chords (62.5% of MB located at the level of RCA and 13.89% of the total MB), being located at the level of the RCA trunk at the level of the coronary, anterior and posterior groove.

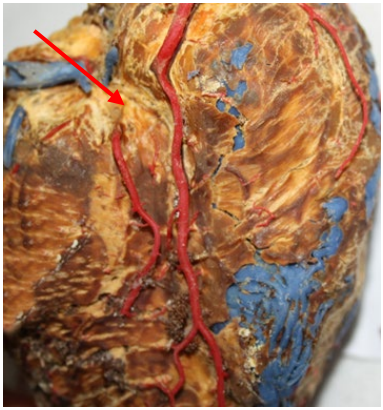


Fig. 18. MB single, superficial, on the ventricular artery; MB It starts from the origin of the artery, having a length of 26 mm (injected heart).

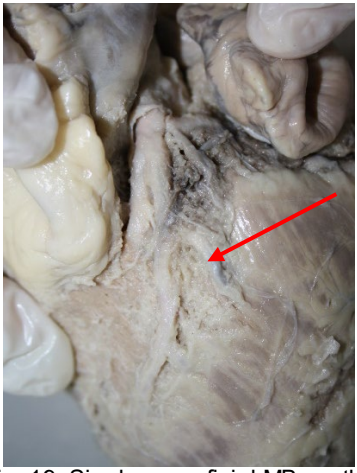


Fig. 19. Single superficial MB, on the diagonal artery; MB It starts from the origin of the diagonal artery in the LAD artery, at a distance of 19 mm from the origin of the diagonal, having a length of 6 mm; diameter of the diagonal artery: originally - 4.5 mm; above MB: 4.5 mm; below MB: 3.5 mm (formalized chord).

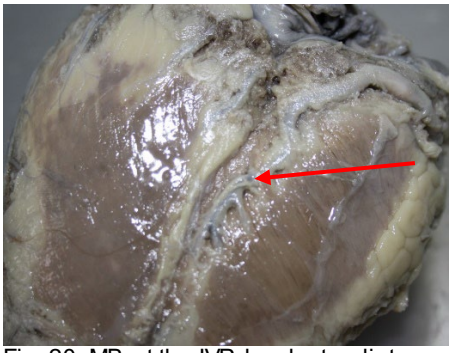


Fig. 20. MB at the IVP level, at a distance of 65 mm from the origin of the right coronary artery in the aorta, having a length of 16.5 mm; IVP diameter: originally - 4 mm; above MB: 3.5 mm; sub MB: 2 mm. (formalized chord).

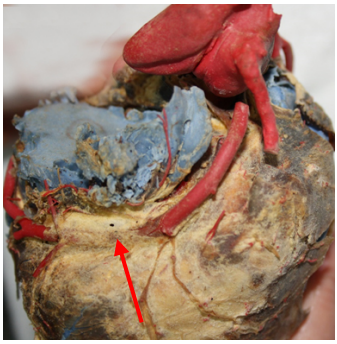


Fig. 21. Superficial MB on RCA in the posterior coronary groove; length: 22 mm; distance from the origin of the LAD artery: 74 mm (injected chord).

DISCUSSIONS

TABLE NR. 2 - MB FREQUENCY IN CASES STUDIED BY DISSECTION.

AUTHOR	NR OF CORPSES (CHORDS)	PERCENTAGE %
Bezera	50	78
Ferreira	90	55,6
Kosinski	100	41
Nalinakumari	30	53,33
Dipal	50	52
Ballesteros	62	40,3
Loukas	200	34,5
Lima	30	86,67
Schwartz	100	41
Ishii	-	50
Wirianta	-	16,3
Theron	-	20
Mohlenkamp	-	25
Personal Cases	***63***	***34,92***

TABLE NR. 8 - MB LENGTH STUDIED BY DISSECTION.

AUTHORUL	LENGTH (MM)	AVERAGE
Kosinski	3,6-42,8	25,7
Nalinakumari	40	-
Dermengiu	10-30	-
Konen	13-40	-
Loukas	31,0	-
Yu-jun Niu	-	21,80
Mohlenkamp	10-30	-
Jin Ho Hwang	-	16,4-27,6
En-sen Ma	8-40	17,6
Kantarci	6-22	17,0
Jacobs	-	23,4
Donkol	6-24	15,0
Ll Jian-Ju	4-40	-
Sirus	-	19,6

Baptista	5,1-41,8	21,5
Ballesteros	-	19,9
Personal Cases	***4,0-42,0***	***-***

TABLE NR. 9 - MB FREQUENCY DEPENDING ON THICKNESS

AUTHOR	**SUPERFICIAL**	**DEEP**	**VENTRIC TYPE. DR.**
Ferreira	75,61%	24,39%	-
Konen	29,41%	41,18%	29,41%
Donkol	61,3%	38,6%	-
Grutta	69,0%	34,57%	-
Sildiroglu	65,43%	34,57%	-
Personal Cases	***92,31%***	***7,69%***	***-***

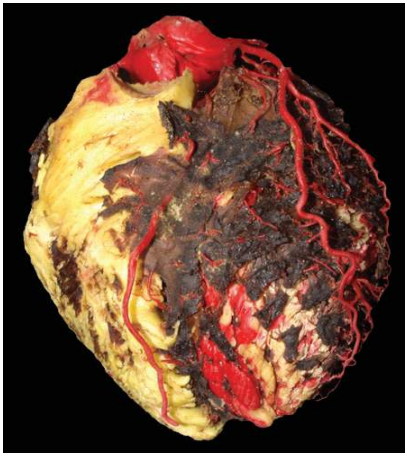


Fig. 32. - Presence of two MB, both complete, on the LAD artery: one upper, in the proximal third of the artery and the other lower, in the middle third, both MB being superficial.

TABLE NR .10 - FULL AND INCOMPLETE MB FREQUENCY ON DISSECTED CHORDS.

AUTHOR	COMPLETE MB	INCOMPLETE MB	MIXED
Carrascosa	55,35%	44,65%	-
Kim SS	18,69% (on LAD)	40,9% (on LAD)	-
Personal Cases	***86,11%***	***8,33%***	***5,56%***

MB MORPHOLOGY DISCOVERED ON ANGIO CT

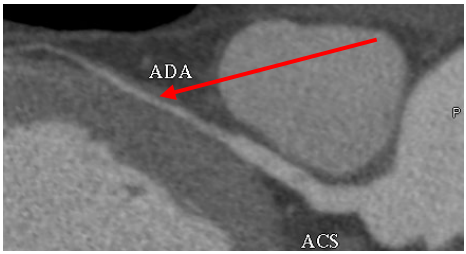


Fig. 33. MB located in the upper 1/3 of the LAD artery (male).

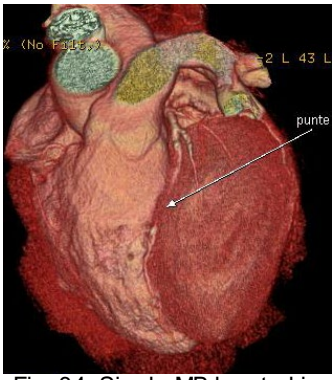


Fig. 34. Single MB located in the middle part of the LAD artery (male).

Out of ***the 284 cases*** with MB found, 250 cases (88.03% of cases) were located at the level of the LAD artery, in 17 cases (5.98% of cases), MB were located at the level of the Cx artery, and also in 17 cases (5.98% of cases), MB were located at the level of RCA.
The 284 cases with MB had a number of ***360 MB***, out of which 189 MB were for males (52.50% of cases) and 171 MB for females (47.5% of cases).

There were ***274 MB of single MB*** (76.11% of the total MB), 133 MB being for males (48.54% of single MB) and 141 MB being for females (51.46% of single MB); There were ***80 MB of double MB***

(22.22% of the total MB), of which 48 MB were for males (60% of double MB) and 32 MB for females (40% of double MB); ***Triple MBs*** numbered 6 MB (1.67% of the total MB), all of which were male (3.17% of the total MB of males).

Fig. 35. Double MB: at the middle 1/3 level of the LAD artery and at the level of the CX artery (male). Single MB on the LAD artery associated with MB on the Cx artery.

MORPHOLOGICAL CHARACTERISTICS OF MB AT THE LEVEL OF LAD ARTERY STUDIED ON CT ANGIOGRAPHS.

At the level of the LAD artery, we found the MBs located in 250 cases (88.03% of the total cases with MB), of which 129 cases were male (51.60% of the cases with MB at the level of the LAD artery) , and in females we found 121 cases (48.40% of cases with MB in the LAD artery).

Numerically, at the level of the LAD artery there were 325 MB, out of which for males there were 164 MB (50.46% of cases), and for females 161 MB (49.54% of cases). There were 244 MB of single MB (74.39% of MB located at the level of the VAT artery), for males being 113 MB (46.30% of the single MB and 68.48% of the total MB located at the VAT level at male) and 131 MB for females (53.69% of single MBs and 80.37% of total MB located at the VAT level for females).

There were ***78 double MB*** (23.78% of MB located at the level of the LAD artery), for males being 46 MB (58.97% of double

MB and 27.88% of the total MB located at the level of VAT at male), and for females 32 MB (31.03% of cases and 19.63% of the total MB located at the VAT level for females).

Triple MBs were 3 MB (0.91% of MB located at the level of the LAD artery), all in males (3.64% of the total MB located at the level of LAD in males).

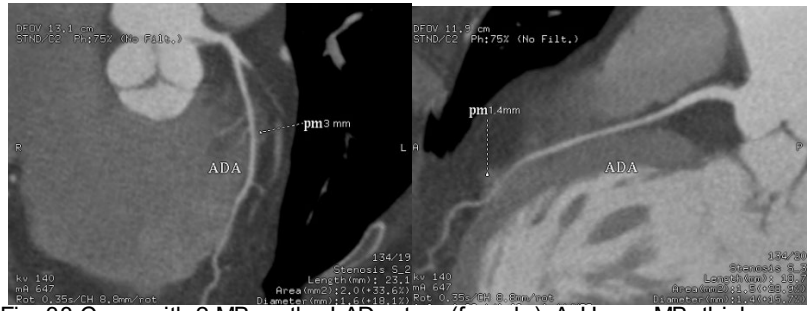


Fig. 38 Case with 2 MB on the LAD artery (female). A. Upper MB: thickness: 3 mm; length: 23.1 mm; tunnel artery diameter: 1.6 mm; area: 2.0 mm2; B. Lower MB: thickness: 1.4 mm; length: 18.7 mm; tunnel artery diameter: 1.4 mm; area: 1.5 mm2.

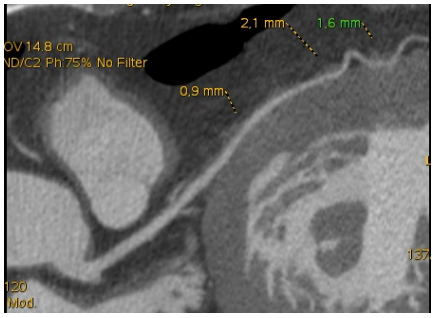


Fig. 39. Case with 3 MB at the level of the LAD artery (male). Upper, in the upper part of the middle 1/3, the diameter of the tunneling artery in systole: 0.9 mm; middle in the lower part of the middle 1/3, the diameter of the tunneling artery in systole: 2.1 mm; lower, in the lower 1/3 of the LAD artery, the diameter of the tunneling artery in systole: 1.6 mm.

MORPHOLOGICAL CHARACTERISTICS OF MB AT THE LEVEL OF THE Cx ARTERY STUDIED ON CT ANGIOGRAPHIES.

found ***MB at the level of the Cx artery*** located in 17 cases (6.59% of the total cases with MB), 13 cases being in the male sex (76.47% of the cases with MB at the level of the CX artery and 4.58% of the total number of cases with MB) and 4 cases being female (23.53% of the cases with MB at the level of the CX artery and 1.55% of the total cases with MB). Of the 17 cases, in 7 cases (41.18% of cases), MB was located in the trunk of the Cx artery, all cases being in the male sex, in 10 cases (58.82% of cases) MB was located in the artery left margin (originating in the Cx artery), 7 cases being in the male sex (70% of cases and 41.18% of the total MB located at the level of the Cx artery) and 3 cases being in the female sex (30% of cases and 17, 65% of the total MB located at the level of artery Cx).

MB were single in 16 cases (94.12% of cases), in only one case, in males, there were double MB (5.56% of cases) in the trunk of the Cx artery, so in total there were 18 MB, 10 MB in the left marginal artery (55.56% of cases) and 8 MB in the trunk of the Cx artery (44.44% of cases).

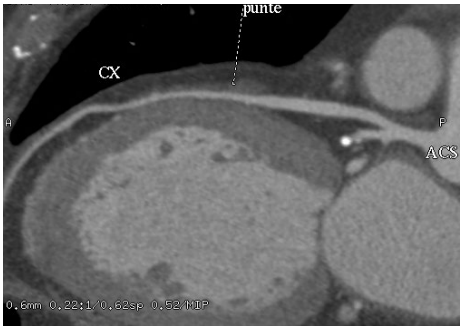


Fig. 40. MB located in the trunk of the Cx artery (male).

MORPHOLOGICAL CHARACTERISTICS OF MB AT RCA LEVEL STUDIED ON CT ANGIOGRAPHS.

MB were located at the level of RCA in ***17 cases*** (5.98% of all cases with MB), 10 cases being in males (58.82% of cases) and 7 cases in females (41.18% of cases). MB had the following disposition:

- In only one case, in females, MB was located on the anterior right ventricular artery originating in RCA (5.88% of cases);
- In 16 cases (94.12% of cases), MB was located at the level of the RCA trunk, 10 cases being in the male sex (62.5% of cases), in the posterior coronary groove, and in 6 cases being in the female sex (37.5% of cases), 2 cases at the level of the posterior coronary ditch (33.33% of cases) and in 4 cases at the level of the IVP ditch (66.67% of cases), originating at different levels of the IVP artery.

In only one case, in males, MB coexisted with MB located on the trunk Cx and on the left margin, in the rest of the cases with MB at the level of RCA, MB were single, being the only MB exists at the level of the coronary arteries.

MB LENGTH DETERMINED ON ANGIO CT AT LAD ARTERY LEVEL

It was studied on 240 cases with MB (87.91% of the total cases with MB), in males being 124 cases with MB (51.67% of cases with MB located at the level of the LAD artery), and in females being 116 cases with MB (48.33% of cases with MB located at the level of the LAD artery).

The cases with ***single MB*** were 202 MB (84.77% of MB located at the level of the LAD artery), in both sexes being 101 cases with single MB (50% of the cases with single MB at the level of the LAD artery and 42.08 % of all cases with MB at the level of the LAD artery) and in males (0.81% of all cases of MB in males).

Out of the 240 cases in which the length of MB was measured at the level of the LAD artery, we found a number of ***312 MB,*** 157 MB being for males (50.32% of MB located on the LAD

artery, 45.38 of the total MB and 83 , 79 of MB in males) and 155 MB in females (49.68% of MB located on the LAD artery, 44.80 of total MB and 95.09% of MB in females).

We found 23 MB of ***single MB*** (75.32% of MB located on the LAD artery and 67.91% of the total MB), 110 MB being for males (46.81% of single MB, 35.26 % of MB located on the LAD artery, 70.06% of male MB located on the LAD artery and 31.79% of the total MB), and 125 MB being female (53.19% of single MB, 40.06% of MB located on the LAD artery, 80.65% of female MB located on the LAD artery and 44.80% of the total MB).

There were 74 ***double MB*** (23.72% of MB located on the LAD artery and 21.39% of the total MB), for males being 44 MB (59.46% of double MB, 14.10% of MB located on the LAD artery, 28.03% of male MB located on the LAD artery and 12.72% of the total MB), and for females being 30 MB (40.54% of double MB, 9.62% of MB located on the artery VAT, 19.35% of female MB located on the VAT artery and 8.67% of the total MB)]

Triple MB were 3 MB in number (0.96% of MB located at the level of the LAD artery, 0.87% of MB located at the level of the LAD artery), being in the male sex (1.91% of male MB located at the level of the artery VAT and 1.64% of total male MB).

The length of the single MB located at the level of the LAD artery, we found it between 4.25-43.10 mm***, in males,*** on the 110 cases, we found the length between 4.25-43.10 mm, and in sex female, on the 125 cases, we found the length between 11.90-35.05 mm. ***At the upper 1/3 of the LAD artery,*** the length was between 5.31-43.10 mm, ***in males,*** on the 72 cases we found a length of MB in the upper 1/3 of the LAD artery between 5, 31-43.10 mm, and in females the 72 cases had a length between 23.0-35.0 mm. ***At the middle 1/3 level of the LAD artery***, presented on the 181 cases, the length was between 4.25-35.0 mm, ***in males*** finding a length between 4.25-32.50 mm, and ***in females*** the 117 cases (64.64% of cases) had a length between 11.9-35.0 mm. *At the lower 1/3 level of the LAD artery*, in the 10 cases the length was between 12.20-16.70 mm.

Fig.41. MB located in the upper 1/3 of the LAD artery; length: 26.9 mm; tunnel artery diameter: 1.6 mm; area: 1.9 mm2 (male).

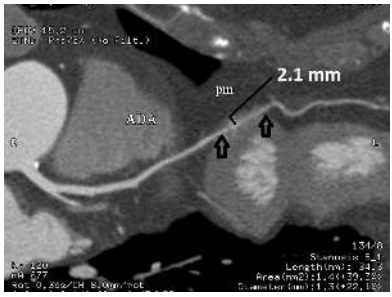


Fig. 42. MB located in the middle 1/3 of the LAD artery; length: 34.3 mm; thickness: 2.1 mm; tunnel artery diameter: 1.3 mm; tunneling artery area: 1.4 mm2 (male).

Fig. 44. MB located in the lower 1/3 of the LAD artery; length: 16.7 mm; thickness: 1.6 mm; diameter of the tunneling area: 1.8 mm; tunneling area: 2.7 mm2 (male).

The length of the double MB located at the level of the LAD artery was found to be between 18.7-25.6 mm, in males, the 44 MB had a length of 20.0-23.7 mm, and in females the length of MB it was between 18.7-25.6 mm.

In both sexes, ***double MB*** located on VAT, upper MB, had a length between 20.0-25.6 mm, and in lower MB the length was between 18.7-23.7 mm.

A B

Fig. 45. A. Double MB (male). The upper MB has a length of 20 mm; the diameter of the tunneling artery is 2.6; the area of the tunneling artery has 5.2 mm2; B. The lower MB has a length of 23.7 mm, the diameter of the tunneling artery is 1.5 mm, and the area of the tunneling artery is 1.9 mm2.

Triple MB located at the level of the LAD artery, found in only one case in males, upper MB, located at the upper 1/3 of the artery, had a length of 43.1 mm, medium MB, located at the middle 1/3 level of the artery, had a length of 11.9 mm, and the lower MB, also located at the middle 1/3 of the artery, had a length of 16.7 mm.

A B C

Fig. 46. Case with 3 MB located at the level of the VAT artery. The upper MB (A) located in the upper part of the middle 1/3, has a length of 43.1 mm, a thickness of 0.9 mm, a diameter of the tunneling artery of 1.7 mm and an area of the tunneling artery of 2.2 mm2; The middle MB (B), located in the lower half of the middle 1/3 of the LAD artery, has a length of 11.9 mm, a thickness of 2.1 mm, a diameter of the tunneling artery of 1.8 mm and an area of the tunneling artery of 2 , 5 mm2; The lower MB (C), located in the lower part of the LAD artery, has a length of 16.7 mm, a thickness of 1.6 mm, a diameter of the 1.8 mm and 1.8 mm dede tunneling artery and the tunnel artery area of 2.5 mm2;

length MB in the circumflex artery was found to be between 24.0-25.60 mm, being lower in the trunk of the circumflex artery (24.0-25.0 mm) and slightly longer in the left marginal artery, with origin in the circumflex artery (25.0-25.6 mm), there being no notable sexual differences in the length of MB at the level of this artery.

Fig. 47. MB located at the level of the Cx artery: length: 25 mm; tunnel artery diameter: 1.5 mm; tunneling artery area: 1.8 mm2.

Fig. 48. MB located in the upper part of the IVP artery; length: 73.1 mm; tunnel artery diameter: 1.3 mm; tunneling artery area: 1.3 mm2.

The MB length at the level of the RCA was found to be between 21.0-73.10 mm, being smaller at the level of the arterial trunk at the level of the coronary groove (21.0-24.0 mm) and more voluminous at the level of the IVP groove (over 24.0 mm), at the level of the IVP artery meeting the highest value of the MP length (73.10 mm).

On the 280 MB ***the thickness*** was between 07-5.7 mm, ***in males*** the 135 MB finding a thickness between 0.9-5.7 mm, and in ***females*** the 145 MB finding them a thickness between 1.5-5.2 mm.

At the level of the LAD artery, the thickness was between 0.7-5.7 mm, ***in males*** the 99 MB presenting a thickness between 0.9-5.7 mm, and ***in females*** the 91 MB finding a thickness between 0.7-5.2 mm

At the upper 1/3 level of the LAD artery we found a thickness between 1.6-3.0 mm, ***in males*** the 26 MB presenting a thickness between 1.6-3.0 mm, and ***in females*** the 19 MB with a thickness between 1.6-3.0 mm. ***At the middle 1/3 level of the LAD artery*** of the 143 MB we found a thickness between 0.7-5.4 mm, ***in***

males the 71 MB presenting a thickness between 0.9-5.4 mm, and ***in females*** of the 72 MB, finding a thickness between 0.7-5.2 mm.

Fig. 49. MB located in the upper 1/3 of the LAD artery (male); thickness: 1.8 mm; length: 32.5 mm; tunnel artery diameter: 1.2 mm; tunneling artery area: 1.2 mm2.

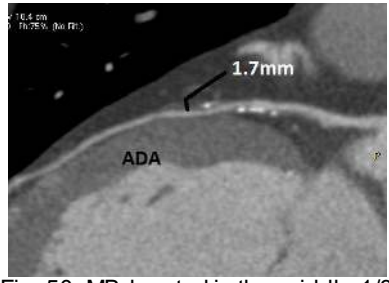


Fig. 50. MB located in the middle 1/3 of the LAD artery. Deck thickness: 1.7 mm (female).

The thickness of MB at the level of RCA was found to be between 2.1-4.1 mm, **for males** it was between 2.6-4.1 mm, and **for females** between 2.1-4.1 mm**.**

The thickness of MB at the left marginal artery was found to be between 2.6-3.7 mm, ***in males,*** the thickness of MB being found to be between 3.3-3.7 mm, and ***in females*** between 2.6- 3.7 mm

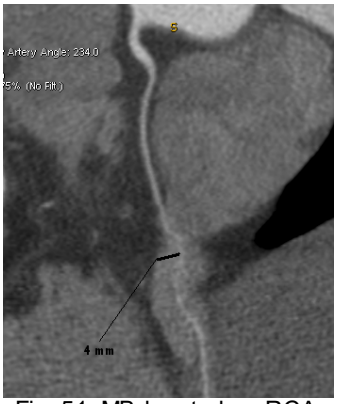


Fig. 51. MB located on RCA: thickness: 4 mm.

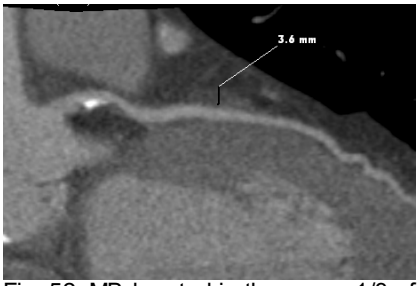


Fig. 52. MB located in the upper 1/3 of the left marginal artery (male: bridge thickness: 3.6 mm.

The thickness of MB at the Cx artery was found to be between 2.4-3.3 mm, ***in males,*** the thickness of MB being between 2.5-3.3 mm, and ***in females,*** between 2.4-3, 0 mm.

DISCUSSIONS

TABLE NR. 11 - FREQUENCY MB

AUTHOR	NR PATIENTS	CASES MB	%	DIFFERENCE %
En-sen Ma	2462	336	13,62	-3,72
Wirianta	934	152	16,27	-6,37
Qian Ju-ying	5525	888	16,70	-6,80
Sildiroglu	412	93	22,57	-12,67
Jodocy	221	51	23,08	-13,18
Yu-Jun Niu	580	140	24,14	-14,24
Donkol	350	89	25,43	-15,53
Zeina	300	78	26,00	-16,10
Yetman	36	10	27,78	-17,88
La Grutta	277	82	29,60	-19,70
Guang-Mig Ju	53	16	30,19	-20,29
Johansen	152	49	32,24	-20,34
Konen	118	36	30,50	-20,60
Rubinshtein	334	117	35,03	-25,03
Carrascosa	452	159	35,18	-25,28
Jin Ho Hwang	1275	536	42,04	-32,14
Kim PJ	300	174	55,95	-46,05
Juillière	7467	61	0,41	+9,49
Sirus	3218	18	0,87	+9,03
Huang Xiao-hong	37463	484	1,20	+8,70
Cay	25982	316	1,22	+8,68
Ll Jian-ju	37106	1000	2,70	+7,20
Kantarci	626	22	3,51	+6,38
Liu H	3011	174	5,74	+4,16
Muzaffer E	1290	94	7,30	+2,60
Irvin	465	35	7,53	+2,37
Personal Cases	***2868***	***284***	***9,90***	***312***

TABLE NR. 12 - MB FREQUENCY REPORTED TO THE NUMBER OF DISCOVERED SUBJECTS

AUTHOR	NR PATIENTS	CASES MB	NR. MB	PERCENTAGE
Jin Ho Hwang	1275	536	557	42,14%
En-sen Ma	2462	336	389	15,80%
Muzaffer E	1290	94	122	9,46%
Gow	200	69	81	24,69%
Konen	118	36	39	39,83%
Personal Cases	***284***	***236***	***360***	***12,68%***

TABLE NR. 13 - FRECVENŢA MB UNICE

AUTHOR	NR MB	NR. MB UNICE
Guang	16	12 (75%)
Liu H	174	168 (96,55%)
Jin Ho Hwang	557	516 (92,64%)
En-sen Ma	389	297 (76,35%)
Personal Cases	***360***	***274 (76,11%)***

TABLE NR. 14 - DOUBLE MB FREQUENCY

AUTHOR	NR MB	NR. MB DOUBLE
Konen	118	11 (9,32%)
Guang	53	3 (18,75%)
Liu H	174	6 (3,45%)
Jin Ho Hwang	536	19 (3,54%)
En-sen Ma	336	39 (11,61%)
Personal Cases	***360***	***80 (22,22%)***

TABLE NR. 15 - FREQUENCY OF MB LOCATION AT LCA LEVEL

AUTHOR	NR MB	LCA
Carrascosa	159	159 (100%)
Wirianta	152	152 (100%)
Donkol	89	89 (100%)
Bastiani	82	86,36%
En-sen Ma	389	288 (74,04%)
Yu-Jun Niu	140	138 (98,57%)

Personal Cases	***360***	***343 (95,28%)***

TABLE NR. 16 - FREQUENCY OF MB LOCATION AT LAD LEVEL

AUTHOR	NR MB	LAD
Irvin	35	35 (100%)
Gow	200	69 (34,5%)
Konen	47	34 (72,34%)
Kantarci	22	22 (100%)
Zeina	78	48 (61,54%)
Carrascosa	159	104 (65,41%)
Liu H	174	167 (95,98%)
Chiung-Zuan Chiu	63	48 (76,19%)
Jin Ho Hwang	557	550 (98,74%)
Jodocy	50	34 (68%)
En-sen Ma	389	235 (60,41%)
Yu-Jun Niu	140	120 (85,71%)
Sildiroglu	93	81 (87,10%)
Personal Cases	***360***	***325 (90,28%)***

TABLE NR. 17 - LOCATION OF SINGLE MYOCARDIAL BRIDGES AT LAD ARTERY LEVEL

AUTHOR	1/3 SUP	1/3 MIJL	1/3 DIST
Irvin	59,12%	-	6,29%
Cay	-	52,79%	47,21%
Kantarci	9,09%	68,18%	22,73%
Konen	-	57,45%	14,89%
Johansen	69,0%	-	-
Carrascosa	-	90,38%	9,62%
Chiung-Zuan Chiu	-	63,49%	12,70%
Qian Ju-ying	40,28%	54,22%	5,50%
Jin Ho Hwang	0,36%	96,18%	3,45%
Wirianta	3,20%	77,60%	9,20%
Donkol	-	24,60%	3,70%
En-sen Ma	-	60,41%	-
Yu-Jun Niu	6,60%	47,50%	9,80%
Personal Cases	***38,78%***	***58,01%***	***3,21%***

TABLE NR. 18 - LOCATION OF MYOCARDIAL BRIDGES

AUTHOR	A. MARG. STG	A. DIAG.STG.	TR. ART. CX
Yu-Jun Niu	5,71%	5,0%	-
En-sen Ma	13,62%	10,80%	-
Donkol	0,80%	2,0%	-
Bastiani	7,32%	3,66%	-
Ballesteros	5,19%	5,19%	-
Loukas	6,17%	17,28%	-
Personal Cases	***2,78%***	***-***	***2,22%***

TABLE NR. 19 – FREQUENCY OF LOCATION OF MYOCARDIAL BRIDGES AT RCA LEVEL

AUTHOR	RCA	IVP	A. MARG. DR.	RAM VENTR ANT.	TR. RCA
Konen	29,41%	-	-	-	-
Yu-Jun Niu	1,43%	-	-	-	-
Dermengiu	15%	-	-	-	-
Arya, Dipal	26,92%	-	-	-	-
Bastiani	-	6,10%	-	-	-
Ishii	36,0%	-	-	-	-
Loukas	25,93%	2,47%	-	-	18,52%
Bezera	-	-	-	12%	-
Personal Cases	***4,72%***	***1,11%***	***-***	***1,11%***	***4,44%***

My result is 3.29% higher than [17], being lower than the results given by [30] by 10.28%, [41] by 21.21%, [42] by 22.20% , [23] by 24.69% and [36] by 31.28%.

The presence of MB on a right anterior ventricular ramus originating in the RCA trunk was found only mentioned by [33], which gives a higher percentage by 10.89% compared to the percentage found by me. The presence of MB in the IVPam artery was found to be 1.36% lower than [41] and 1.28% compared to [28], and the presence of MB in the RCA kit at the coronary groove was found to be lower in 14.08% in relation to the percentage given by [41]. We

did not find the presence of MB on the right marginal artery, an aspect reported by [41], 4.93% of cases.
[13, 18] did not encounter the presence of MB at the level of RCA.

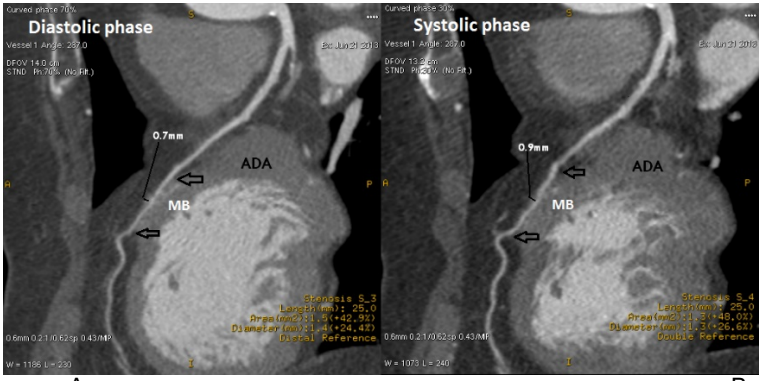
THICKNESS OF MYOCARDIAL BRIDGES

TABLE NR. 20 - GENERAL THICKNESS OF MB.

AUTHOR	Thickness (mm)	Average (mm)
Kantarci	1,20-3,30	2,50
Guang	1,0-3,55	-
Kosinski	1,0-3,8	-
Jacobs	-	2,60
Jin Ho Hwang	-	3,0
Jodocy	-	2,60
Donkol	1,0-6,2	2,30
En-sen Ma	1,60-5,0	2,70
Yu Jun Niu	-	2,15
Muzafer E	0,5-7,0	-
Basso	2,0-8,0	-
Personal Cases Male:1,7-5,7; Female:0,7-5,2.	0,70-5,70	3,01

A B

Fig. 59. AMB in the upper middle third of the LAD artery (male). Bridge thickness in systole: 2.7 mm. B. Bridge thickness in diastole: 1.8 mm (difference in systole / diastole thickness being 0.9mm

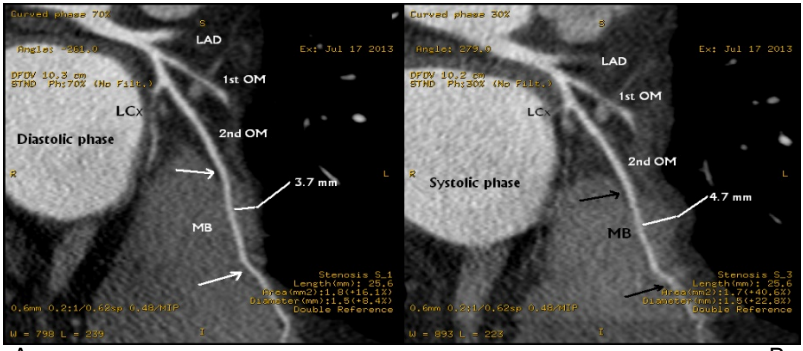


A. B.

Fig. 60. MB located in the middle 1/3 of the LAD artery (female). A. diastole. Bridge thickness: 0.7 mm; length: 25 mm; tunnel artery diameter: 1.4 mm; area: 1.5 mm2; B. systole. Bridge thickness: 0.9 mm; length: 25 mm; tunnel artery diameter: 1.3 mm; area: 1.3 mm2.

TABLE NR. 21 – MB CLASSIFICATION ACCORDING TO THICKNESS.

AUTHOR	NR. CASES	THICKNESS	SUPERF.	PROF	TYPE VENTR. DR.
Ferreira	41	< 2 mm	75,61%	24,39%	-
Konen	34		29,41%	41,18%	29,41%
Donkol	-	< 1 mm	61,3%	38,6%	-
Grutta	-	-	69,0%	31,0%	-
Sildiroglu	81	-	65,43%	34,57%	-
Kim SS	198	-	59,60%	34,57%	-
Personal Cases	***280***	***< 2 mm***	***42,31%***	***57,69%***	***-***



A. B.

Fig. 61. Male. MB located on the left marginal artery, originating in the Cx artery (male). A. The diastolic phase. MB thickness: 3.7 mm; length: 25.6 mm; tunnel artery diameter: 1.5 mm; tunneling artery area: 1.8 mm2. B. Systolic phase. MB thickness: 4.7 mm; length: 25.6 mm; tunnel artery diameter: 1.5 mm; tunneling artery area: 1.8 mm2.

A. B.

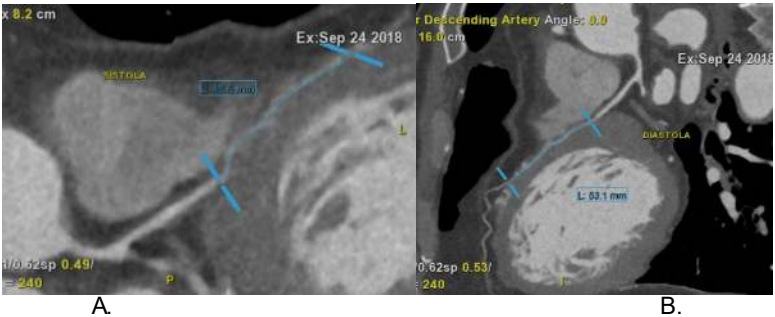
Fig. 62. MB located in the upper 1/3 of the IVP artery (female). A. The systolic phase. MB thickness: 1.2 mm; length: 21.2 mm; tunnel artery diameter: 2.2 mm; tunneling artery area: 3.9 mm2. B. Diastolic phase. MB thickness: 1.1 mm; length (mm): 24.4; diameter: 2.4 mm; tunneling artery area: 4.5 mm2.

TABLE NR. 22 - FREQUENCY MB COMPLETE AND INCOMPLETE

AUTHOR	MB COMPLETE	MB INCOMPLETE
Carrascosa	55,35%	44,65%
Kim PJ	62,24%	32,76%
Kim SS (LAD)	18,69%	40,90%
Personal Cases	***49,29%***	***50,71%***

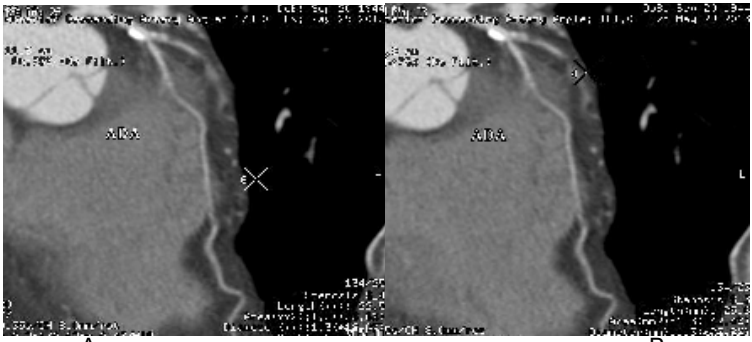
TABLE NR. 23 – LENGTH MB

AUTHOR	LENGTH (MM)	AVERAGE LENGTH (MM)
Kantarci	6,0-120	17,0
Konen	13,0-40,0	-
Sirus	-	19,60
Guang	-	2,32
Liu H	5,0-120	30,50
Qian Ju-Ying	-	20,90
LI Jian-Ju	4,0-40 ,0	-
Donkol	6,0-24,0	15,0
En-sen Ma	8,0-40,0	17,60
Yu-Jun Niu	-	21,80
Jodocy	-	14,80
Muzafer	5,0-40,0	-
Personal Cases	4,25-73,10 M: 4,25-73,10 F:11,90-35,05	26,51 28,95 12,66.



A. B.

Fig. 63. MB at the middle 1 / 3-1 / 3 level of the LAD artery (male). The length of MB in systole (A) is 45.6 mm, and in diastole (B) the length of MB is 53.1 mm, the difference being 7.5 mm.



A. B.

Fig. 64. MB at the middle 1/3 level of the LAD artery (female). The length of MB in systole (A) is 22.5 mm, and in diastole (B) the length of MB is 25.6 mm, the difference being 3.1 mm.

TABLE NR. 24 – TUNNEL ARTERY CALIBER IN SYSTOL

AUTHOR	CALIBRUL (MM)
Konen	1,6
Donkol	1,6
En-sen Ma	0,3-2,3 (average: 1,1, in the middle of LAD)
Liu H	1,3-2,8 (average 2,3)
Personal Cases M:1,2-2,6 (average:1,60); F:1,2-1,9 (average:1,58).	***1,2-2,6 (average:1,58);***

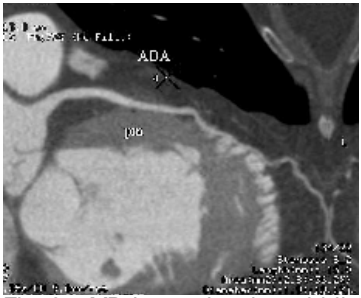


Fig. 65. MB located at the middle 1/3 of the LAD artery (female), the diameter of the tunneling artery having 1.9 mm.

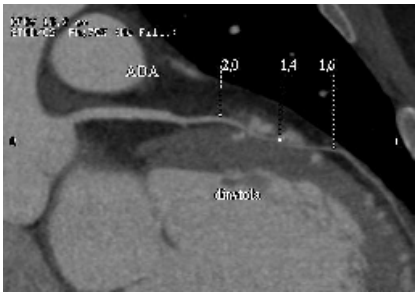


Fig. 66. MB located in the middle 1/3 of the LAD artery (male). Diameter of the tunneling artery in diastole: upstream-2 mm; at the level of MB-1.4 mm; downstream-1.6 mm.

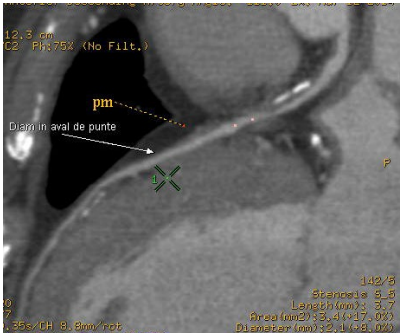


Fig. 67. MB at the middle 1/3 level of the LAD artery (male). Downstream of MB the diameter of the tunneled artery is 2.1 mm, at the level of MB having 1.9 mm.

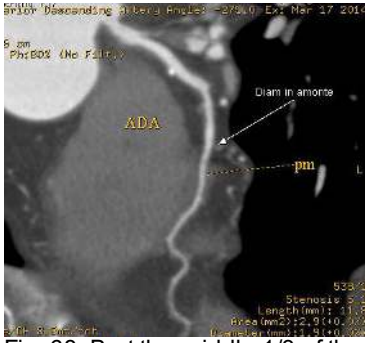


Fig. 68. B at the middle 1/3 of the LADartery (female). Upstream, the diameter of the tunneling artery has the same size as at the level of MB: 1.9 mm.

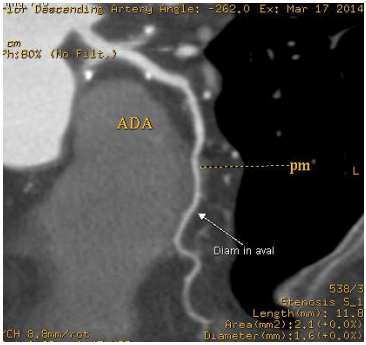


Fig. 69. Downstream the diameter is 1.6 mm, being small by 0.3 mm.

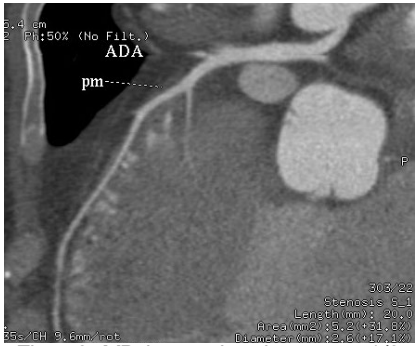


Fig. 70. MB located at the upper 1/3 limit with the middle 1/3 of the LAD artery (male). The diameter of the tunneling artery is 2.6 mm.

GENERAL DISCUSSIONS

Making a comparison between the results obtained on MB by dissection, with the results obtained by studying CT angiographies, we found similarities, but also some differences that resulted from using the two working methods.

A first difference consists in the number of cases on which the study was performed: by dissection we worked on 63 human chords, discovering MB on a number of 22 chords (34.92% of cases), which presented a number of 36 MB. Angiographs analyzed the angio CT scans of a number of 2868 people, of which 284 presented MB (9.90% of cases), totaling a number of 363 MB.

There is therefore an appreciable disproportion between the number of cases, on the one hand, as well as in the number of MB, on the other hand, the cases on angio CT being more than 10 times more numerous.

This difference causes the percentages of the different characteristics of the MB to vary, sometimes appreciably, between the two working methods.

Another difference is that on CT angio, the cases were analyzed according to sex, which was not done in the cases studied by dissection. Also, on the CT angio were recorded the age of the person, as well as another series of morphological characteristics of MB, measured electronically: thickness, length, diameters of the tunneling vessel (at MB level, above and below it), by dissection these measurements performed manually (with the caliper).

In general, by the two working methods MB were discovered on the same coronary artery branches: LAD (most frequently, by both working methods), Cx (arterial trunk and left margin, originating in the trunk Cx), the trunk RCA (at the level of the coronary ditch and the IVP ditch). By both methods we found the reduced number of MB in the lower 1/3 of the LAD artery, as well as the reduced number of triple MB (on the same artery or on different arteries of the same chord), not describing any case with more than 3 MB.

Through CT angiography we did not find MB on the right anterior ventricular branch, originating in the RCA trunk at the level of the

anterior coronary groove and at the level of the LAD artery. We also did not find MB that has a double morphological characteristic: superficial and incomplete, initially, followed by a complete and deep MB, this variant of MB being found at the level of the Cx artery, the posterior coronary fossa.

Differences between the two methods were found in MB morphometry. This explains that by angio CT the measurements are performed live (on the functional organism), the measurements can be performed during the two phases of the heart revolution, systole and diastole, thus recording the differences between morphological characteristics, very important in the clinic. MB. These characteristics in systole and diastole cannot be assessed by dissection.

At the level of MB length, a dissection shows a value between 4.0-42.0 mm, by angio CT the length being much longer: 4.25-73.1 mm, and if we eliminate the maximum value found by angio CT (found in only one case), the maximum value is also higher (44.0 mm).

By dissection, the thickness of MB could not be appreciated, appreciating only the length and diameter of the tunneling artery, at the level of its origin.

By dissection we measured the distance between the origin in the main arterial trunk of the tunneling artery and the MB extremity, a feature not recorded on CT angio.

On the CT angio, the diameters of the tunneling artery were measured at the level of MB, above and below it, both in systole and in diastole, an aspect that could not be recorded by dissection. Also, by CT angiography, the area (surface) of the tunneling artery was measured at MB level, a characteristic closely related to the diameter of the tunneling artery.

Angio CT allows the assessment of the degree of arterial stenosis, as well as the highlighting of the presence, location and degree of atherosclerosis of the artery in relation to the location of MB.

I found atherosclerosis frequently present proximal MB, both in males and females, finding no case with atherosclerosis at MB level and very rarely encountering atherosclerotic plaques below MB level, coexisting with atherosclerotic plaques above MB.

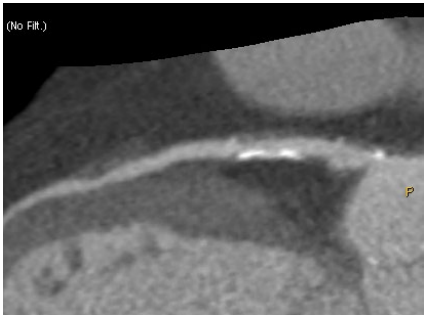


Fig. 71. MB located in the upper 1/3 of the LAD artery, with the presence of atherosclerosis above the MB (male).

CONCLUSIONS

The topic of myocardial bridges, although much debated in the literature, as evidenced by the large number of papers that address this topic, still has many features less well specified or even not described so far. A comprehensive study addressing the macroscopic, morphopathological and clinical features of MB and microscopic changes in the vascular-muscular components of MB has not yet been performed.

My study is certainly singular in this area of Romania, dealing with the morphological characteristics of MBs in the branches of coronary arteries in almost all morphological aspects. At the same time, a comparison is made of the characteristics of MBs with the results described by authors from all parts of the globe, as can be seen in the thesis and in the literature presented.

My results were obtained by dissection and by the study of coronary angiography CT.

Given the long, sometimes asymptomatic, survival of people with MB, some authors consider MB as a common (normal), benign variant, which cannot be considered an important cardiovascular risk factor.

Other authors specify the severity of MB, taking into account the disorders it can cause: arterial compression (stenosis), angina, hypertrophic myocardopathy, arrhythmias, myocardial infarction).

The improvement of the imaging means and of the working software, make that between the detection by dissection and the imaging one no longer there are very big differences, as they existed 20-30 years ago, the imaging being able to detect MB with a thickness of less than 1 mm.

MBs are congenital diseases that raise important clinical problems through their complications, which often go to sudden death, the severity of an MB being given by its length and especially its thickness, which are responsible for the degree of compression of the tunneling artery.

We did not encounter cases of MB affecting the anterior interventricular arterial branch along its entire length and we also encountered less frequent localization of MB at its terminal 1/3 level.

Given the frequency of complications in people with MB (see sudden deaths on sports grounds or at work), control of coronary vascularization by angioCT is required, especially in high-performance athletes or people who exert great effort in exercising the profession, even when the person does not show any symptoms, thus making an active detection among the population. Last but not least, the importance of the presence of MB for heart transplantation should be emphasized.

The existing statistical differences in the literature are explained by the number of cases on which the study was performed, by the performance of the device worked on and by the attention and experience of the staff working in the respective medical service. We do not exclude the predisposition to MB frequency depending on the geographical area or even according to ethnicity. Equally important is the arterial segment at which the MB is located.

ORIGINALITY OF THE THESIS

- The use of two working methods: dissection and study of CT angiographies, as well as comparison between them of the morphological results obtained by the two methods.
- The relatively large number of cases on which the morphological characteristics of MB were determined, especially the number of CT angiographies.
- Dissection on plastic injected cords and precise highlighting of MB.
- Study of the morphological characteristics of MB according to sex.
- MB morphometry (length, thickness, distance from the origin of the artery, diameter of the tunneling artery) studied on arteries: LAD, Cx, left margin and RCA.
- Specify the number of MB for each case that had MB.
- Specify the distance between the origin of the artery at which the MB was located and the upper edge of the MB.
- MB study located at the level of the LAD artery on the three segments of the artery: 1/3 upper, 1/3 middle and 1/3 lower.
- Presentation of MB at the level of RCA separated on the arterial trunk at the level of the coronary ditch and on the IVP artery, at the level of the homonymous ditch.
- Morphological characteristics of MB that we did not find cited in the studied literature:
- Classification of single MB, especially at the level of the LAD artery, into single arteries proper and single MB on the LAD artery, associated with MB located on other arteries of the same chord.
- Classification of multiple MB (double or triple) into multiple MB on the same artery (LAD or CXA) and multiple MB located on different arteries of the same chord.
- -Classification MB according to their length in short, medium, long and very long.

- Double MB (two cases by dissection) at the trunk of the Cx artery on dissected chords.
- MB at superficial and incomplete origin, later becoming complete and deep, at the level of the Cx artery in the posterior coronary groove.
- Presence of MB in the anterior right ventricular arteries, originating from the RCA and the LAD artery.

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