DOI 10.2478/v10181-010-0011-6

Original article

Distribution of myocardial bridges in domestic pig

A. Kosiński[1], M. Grzybiak[1], D. Kozłowski[2]

[1] Department of Clinical Anatomy, Medical University of Gdańsk, Dębinki 1, 80-210 Gdańsk, Poland
[2] 2nd Department of Cardiology, Medical University of Gdańsk, Dębinki 7, 80-210 Gdańsk, Poland

Abstract

Localisation and morphology of myocardial bridges in the heart of domestic pig remain an open issue. Since these structures significantly influence haemodynamics in the coronary arteries, their occurance may lead to numerous pathologies. In the examined group of 150 domestic pig's hearts, myocardial bridges were diagnosed in 47.3% of the material, mostly in males. In majority of cases the bridges were present above the posterior interventricular branch of the right coronary artery, less often above the anterior interventricular branch of the left coronary artery, and seldom above other blood vessels. The presence of myocardial bridges usually referred to the medial and initial segments of the arteries examined.

Key words: myocardial bridge, pig, heart, ischemia

Introduction

Myocardial bridges (MB) are structures formed of heart muscular tissue and located over coronar arteries and their branches (Fig. 1). Despite numerous analyses, there still exist many discrepancies within the subject. Most controversies arose about the origin of the myocardial bridges and their morphology. Opinions also differ when the influence of the MB on haemodynamic processes in coronal vessel system is concerned. Majority of authors agree that myocardial bridges may induce ischaemia in muscularis externa located distally from the MB through compression of blood vessels during myocardial contraction (Calcagno et al. 1994). Besides, the notion of possible significant influence of MB's on modifying arteriosclerotic processes withing the bridging vessel is also gaining popularity.

Although there are relatively many case studies of myocardial bridges in human hearts, the analyses of the subject based on animal material are not that rich. The first extensive study on the issue comparing different species of mammals dates from 1968. Its authors, Polacek and Zechmeister, presented a concept of classifying mammals into three types based on the criterion of MB presence (Polacek and Zechmeister 1968). The research was done gradually, not only in for its phylogenetic aspect, but also with the aim of using it in veterinary.

The present study opens a planned series of articles devoted to the issue of myocardial bridges. The subject area for further analyses will cover morphological aspects of MB with a macro- and microscopic approach.

Materials and Methods

The research was done on 150 domestic pig's hearts (*Sus* (*Sus*) *scrofa domestica* (Linnaeus 1758))

Correspondence to: A. Kosiński, e-mail: akoi@interia.pl, tel.: +48(58) 3491420

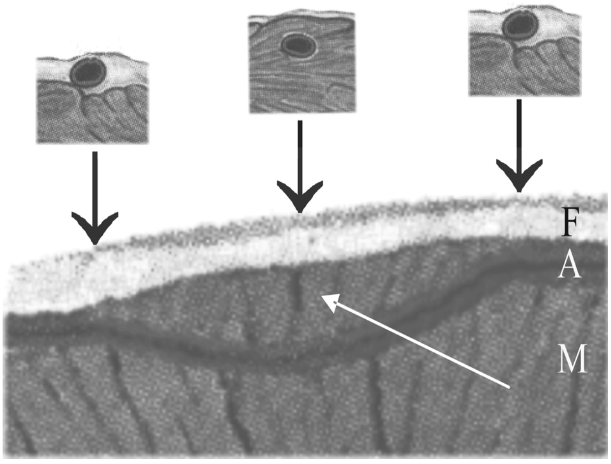

Fig. 1. Myocardial bridge (white arrow). F – fat tissue, A – artery, M – myocardium.

(Artiodactyla, Suidae), cross-breeds of Polish Landrace and Pietrain. The material preserved in a mixture of formalin and ethanol solution was composed of 88 male hearts and 62 female hearts. The hearts aged between 6-9 months (due to incomplete data, detailed distintinction according to age was not made). In the study organs with no macroscopic developmental anomalies were used.

The following arteries were analysed: right coronary artery (ACD), left coronary artery (ACS) and their main branches – right marginal branch (Rmd), posterior interventricular branch of the right coronary artery (Rip), anterior interventricular branch of the left coronary artery (RIA), left circumflex artery (RCX) and diagonal arteries (Rd).

Each of the examined arteries was divided into 5-milimeter segments starting from the branching of the aortic bulb to the level at which its external diameter was 1 mm. The cuts were made perpendicularly to the long axis of the artery, through the middle of each segment and on their adjacencies. In case MB was observed, apart from standard cuts, additional incisions were made every 1-2 mm. Thanks to this procedure the starting and ending points of MB could be precisely determined. With the use of a set of magnifying glasses of different zoom (2-8x) the image of the cross sections of the artery and adjacent structures was analysed. The frequency of MB's occurrence and its location were evaluated. Apart from these, each examined artery was divided into three uniform segments called thirds. The location of a bridge above a specific artery was determined through assigning it to this third in which more than $^3/_4$ of its length were located. The selected part of the material was evaluated with the use of statistic methods (chi-square test).

Results

The presence of myocardial bridges (MB) was confirmed in 71 hearts which accounts for 47.3% of the examined group. The structures were observed more often in male hearts (45 hearts – 51.1% of the examined male hearts), and more saldom in female hearts (26 hearts – 41.9% of the examined female hearts), but differences were not statisticaly significant (Fig. 2). In total 81 myocardial bridges were

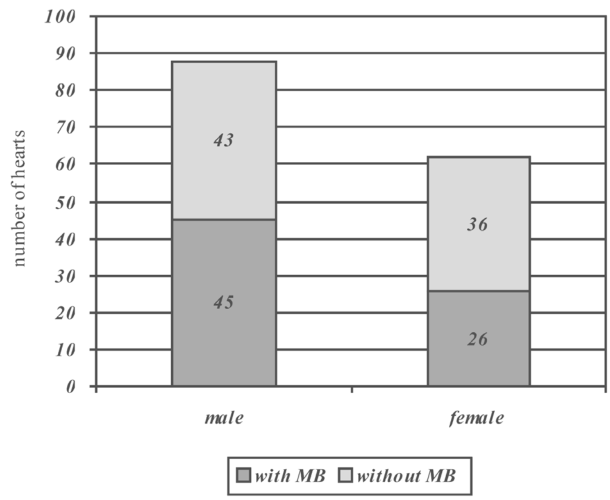

Fig. 2. Number of hearts with myocardial bridges (MB), separately in male and female material.

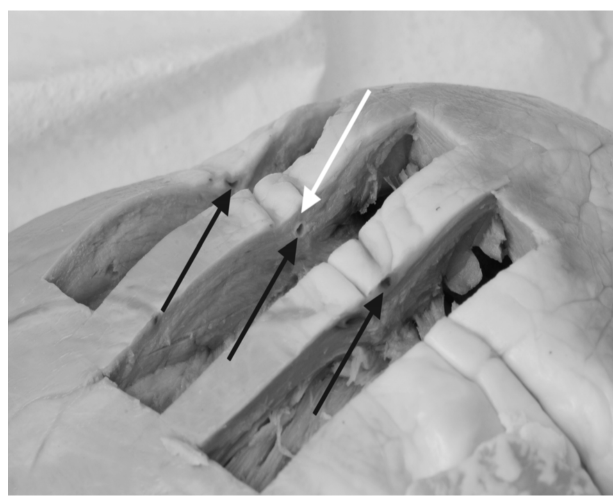

Fig. 3. Myocardial bridge (white arrow) above the posterior interventricular branch (black arrows),♂

observed located above five vessels: the anterior interventricular branch of the left coronary artery, posterior interventricular branch of the right coronary artery, first diagonal branch of left coronary artery (Rd), right marginal branch (Rmd) and left circumflex artery (RCX). The bridges were observed mainly above Rip (37 MBs in 34 hearts) (Fig. 3), and more rarely over remaining vessels: RIA – 30 MBs in 27 hearts (Fig. 4), Rd – 8 MBs in 8 hearts, RCX – 4 MBs in 4 hearts and Rmd – 2 MBs in 2 hearts (Fig. 5). When analysing the results in reference to the total number of bridges, the following values were obtained: 45.7% of the total MBs were present above Rip, 37% above RIA, 9.9% above Rd, 4.9% above RCX and 2.5% above Rmd (Table 1).

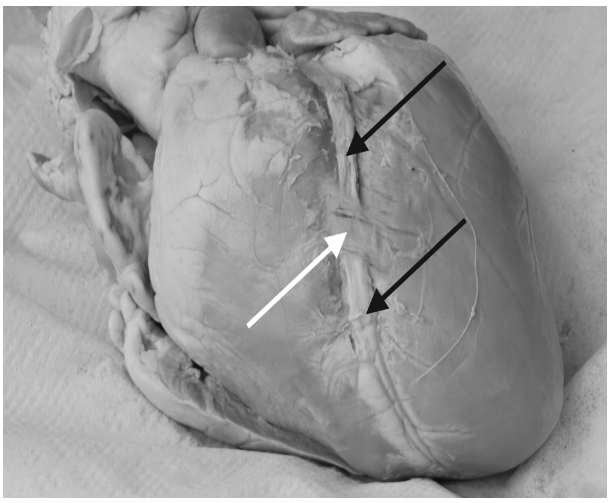

Fig. 4. Myocardial bridge (white arrow) above the anterior interventricular branch (black arrows),♂

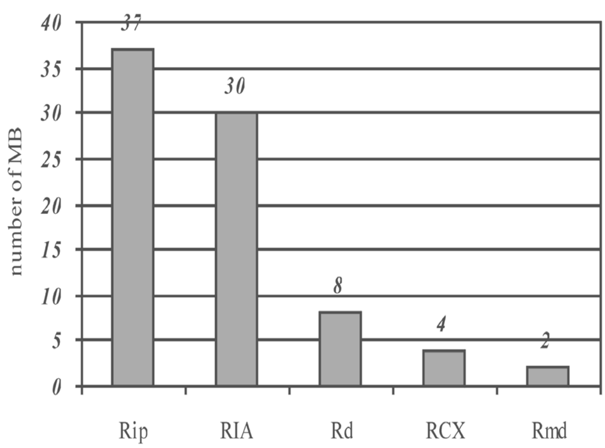

Fig. 5. The number of myocardial bridges (MB) above specific vessels.

Table 1.Quantitative distribution of myocardial bridges (MB) above specific vessels.

	Rip	RIA	Rd	RCX	Rmd
Number of MB	37	30	8	4	2
% MB	45.7	37.0	9.9	4.9	2.5
Number of hearts with MB	34	27	8	4	2
% of material	22.7	18.0	5.3	2.7	1.3

On the basis of the research, three types of MB's location were established. In type I, the most frequent case (61 hearts – 85.9% hearts with bridges), one MB was present in heart. Type II was observed in far fewer cases (two MBs in heart above the same vessel) – 6 hearts (8.5% hearts with bridges) and type III (two MBs in heart above different vessels) – 4 hearts (5.6% hearts with bridges).

In type I myocardial bridges were observed above each kind of examined arteries – mostly above Rip (28 hearts – 18.7%), more rarely above remaining vessels – RIA (20 hearts – 13.3%), Rd (8 hearts – 5.3%), RCX (3 hearts – 2%) and Rmd (2 hearts – 1.3%). Type II applied to hearts with bridges above Rip and RIA (3 hearts – 2% each), whereas in type III 3 hearts (2%) with MB above RIA and Rip and 1 heart (0.7%) with MB above RIA and RCX were classified.

The location of MB above a certain artery was estimated in reference to one of the three thirds of the examined vessel. Most bridges referred to the middle third, and then to the first one. In some cases MB were not observed above the distal segment of the artery.

Discussion

Although the phenomenon of muscle bridges has been a subject of numerous research projects, their conclusions are not homogeneous. The first descriptions of MB date back to 18th century (Reyman 1737). Since then 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 frequency of occurrence of MB in humans seems to raise most controversies and is estimated to be 5-86% (Angelini et al. 1983). According to Polacek such a large discrepancy results from insufficient precision of dissection studies (Polacek 1961). In that study, he analysed a few dozen hearts, in 6% of which during routine anatomopathologic examination the bridges above RIA were observed, while in the same material he revealed MB in 60%. The number of hearts analysed as well as used methodology based on scrupulous analyses of cross-sectional pictures of the vessels, seem to guarantee MB detection. Moreover, in literature on this subject one may find data confirming a posibility of using gel substances to inject coronary arteries in order to visualise the structures (Aleksandrowicz et al. 1993). Such techniques, however, do not assure better precision of observation (Baptista and DiDio 1992).

Research on myocardial bridges in animal material is done occasionally. Berg detected the presence of MB in 107 pig's hearts which accounts for 24.3% of the material. What should be emphasised, however, is the fact that his observations were limited exclusively to the right coronary artery and the middle cardiac vein. The results obtained in our experiment in reference to Rip and Rmd are similar. When analysing hearts of various animal species, Van Nie and Vincent detected MB in one examined pig's heart (Van Nie and Vincent 1989). Moreover, the structures occurred, *inter alia*, in monkeys, sheep, dogs and seals. Relatively abundant data concerning the presence of MB in domestic pig's heart was presented by Aleksandrowicz et al. (1993). The observations were made on material composed of 30 hearts, by means of injecting the vessels with latex. Myocardial bridges were detected in 86.6% of the examined organs. The structures were then classified according to Polack as muscle ansae, muscle bridges and muscle tunnels (Aleksandrowicz et al. 1993). It seems that such a large number of detected MBs may have resulted from a thorough analysis of numerous tiny artery branches.

According to contemporary data, the presence of the bridge in human heart is connected with RIA, mainly with the medial segment of the artery (Ferreira et al. 1991, Stolte et al. 1997). In turn, there are not enough detailed reviews on location of MB in pig's heart. In our researches the bridges were observed primarily above Rip, more rarely above RIA and sporadically above other arteries. They usually concerned central or initial segments of the vessels (the second or first third). Obtained results as well as literature on the subject undoubtfully suggest the presence of MB mostly above branches located in interventricular sulci. The nature of this coincidence should supposedly be investigated through analysing the phenomena accompanying processes of development of coronary vessels during fetal stage (Patten 1927).

Moreover, we have also detected rare bridges above heart veins – single reports describe that rare phenomenon. According to Berg, frequent location of MB migth be middle cardiac vein (Berg 1963), whereas Ratajczyk-Pakalska additionaly reports great cardiac vein (Ratajczyk-Pakalska 1974).

There are numerous reports in literature confirming the fact of MB's influence on haemodynamic processes in coronary vessels. The most fundamental problem seems to concern generating ischaemic episodes (Bashour et al. 1997, Konduracka et al. 1997). There have been many accounts of cardiac arrhythmia, myocardial infarction or sudden cardiac death with MB being the only possible cause (Bestetti et al. 1991, Konduracka 1994). The mechanism of the phenomenon is based on compression of coronary artery during systolic phase, which results in reduction of the area of the vessel's cross-section. Due to anatomical similarity to human heart and comparable model of coronary blood distribution, it is suspected that the described processes run analogically in pig's hearts. Besides, the compression caused by MB generates deformation of laminar flow's structure, which results in disturbance damaging the endothelial tissue. The destruction of vascular ephitelium intensifies the development of sclerotic changes and further occlusion of the artery (Winter et al. 1998).

In the course of conducted studies, human coronary system nomenclature was used. Data from subject literature undoubtfully recommends such an interpretation indicating the substantial isomorphism of both systems (Sahni et al. 2008). In addition, in all examined cases there appeared a variation in which Rip constituted a branch of ACD. The fact of "right-side vascularity" domination in pig's heart also finds confirmation in the literature (Weaver et al. 1986).

The presented compilation opens a series of articles connected with the problem of myocardial bridges. Due to substantial importance of the discussed structures, more thorough research based on further observations seems to be fully justified.

References

Aleksandrowicz R, Balwierz P, Barczak R, Stryjewska-Makuch G (**1993**) Myocardial structures over the coronary arteries and their branches. Folia Morphol 52: 183-90.

Angelini P, Trivellato M, Donis J, Leachman RD (**1983**) Myocardial bridges: a review. Prog Cardiovasc Dis 26: 75--88.

Baptista CA, DiDio LJ (**1992**) The relationship between the directions of myocardial bridges and of the branches of the coronary arteries in the human heart. Surg Radiol Anat 14: 137-140.

Bashour TT, Espinosa E, Blumenthal J, Wong T, Mason DT (**1997**) Myocardial infarction caused by coronary artery myocardial bridge. Am Heart J 133: 473-477.

Berg R (**1963**) On the presence of myocardial bridges over the coronary vessels in swine (Sus scrofa domesticus). Anat Anz 112: 25-31.

Bestetti RB, Costa RS, Kazava DK, Oliveira JS (**1991**) Can isolated myocardial bridging of the left anterior descending coronary artery be associated with sudden death during exercise? Acta Cardiol 46: 27-30.

Calcagno S, Cesari D, Gallo R, D'Andrea B, Cervellini P, Iacomelli M (**1994**) Myocardial bridge and ischemic cardiopathy: Clinical case of myocardial bridge of the right coronary artery in an asymptomatic subject. Cuore 11: 73-78.

Ferreira AG Jr, Trotter SE, König B Jr, Decourt LV, Fox K, Olsen EG (**1991**) Myocardial bridges: morphological and functional aspects. Br Heart J 66: 364-367.

Konduracka E (**1994**) Myocardial infarction in 15-years old patient with myocardial bridge narrowing the lumen of left anterior descending artery. Kardiol Pol 41: 313-316.

Konduracka E, Piwowarska W, Kitliński M (**1997**) Myocardial bridge of the coronary arteries and its clinical significance. Pol Merk Lek 14: 86-88.

Patten B (**1927**) The embryology of the pig. 1st ed., P Blakiston's Son & Co., Philadelphia.

Polacek P (**1961**) Myocardial infarct and muscular bridges and loops on the coronary arteries. Ark Patol 23: 23-29.
Polacek P, Zechmeister A (**1968**) The occurrence and significance of myocardial bridges and loops on coronary arteries. In: V. Krutna, ed. Monograph 36, Opuscola Cardiologica. Acta Facultatis Medicae Universitatis Brunenses. University JE Purkinje: Brno, 1968, pp. 1-99.
Ratajczyk-Pakalska E (**1974**) Studies on the cardiac veins in man and the domestic pig. Folia Morphol 33: 373-384.
Reyman HC (**1737**) Dissertatio de vasis cordis propriis. Haller Bibl Anat 2: 366.
Sahni D, Kaur GD, Jit H, Jit I (**2008**) Anatomy and distribution of coronary arteries in pig comparison with man. Indian J Med Res 127: 564-570.
Stolte M, Weis P, Prestele H (**1977**) Muscle bridges over the left anterior descending coronary artery: Their influence on arterial disease. Virchows Arch A 375: 23-36.
Van Nie CJ, Vincent JG (**1989**) Myocardial bridges in animals. Anat Histol Embryol 18: 45-51.
Weaver ME, Pantely GA, Bristow JD, Ladley HD (**1986**) A quantitative study of the anatomy and distribution of coronary arteries in swine in comparison with other animals and man. Cardiovasc Res 20: 907-917.
de Winter RJ, Kok WE, Piek JJ (**1998**) Coronary atherosclerosis within a myocardial bridge, not a benign condition. Heart 80: 91-93.