ORIGINAL ARTICLE

Prevalence and clinical presentation of myocardial bridge on the basis of the National Polish Percutaneous Interventions Registry and the Classification of Rare Cardiovascular Diseases

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KEY WORDS
angiography, CRCD classification, myocardial bridge, National Polish Percutaneous Interventions Registry

ABSTRACT

BACKGROUND A myocardial bridge (MB) is defined as a congenital anomaly, in which a segment of an epicardial coronary artery takes an intramuscular course.

AIMS The aim of the study was to evaluate the prevalence of MB in coronary arteries among patients who were diagnosed using coronary angiography.

METHODS Data were obtained from the National Polish Percutaneous Interventions Registry for patients hospitalized between January 1, 2014, and December 31, 2016, in invasive cardiology departments in Poland and divided into groups with and without MB.

RESULTS The study included 298 558 patients. The non-MB group comprised 296 133 patients (99.19%; women, 38.01%), while the MB group included 2425 patients (0.81%; women, 39.98%). The most frequent location of MB was the left anterior descending artery (n = 2355; 97.11% of patients). The MB group less often had diabetes (14.68% vs 21.63%), previous stroke (1.61% vs 2.96%), previous myocardial infarction (10.97% vs 21.97%), kidney disease (2.8% vs 5.04%), previous coronary artery bypass graft (1.03% vs 5.64%), previous percutaneous coronary intervention (13.20% vs 25.86%) than the non-MB group (P <0.0001). The incidence of acute coronary syndromes was lower in the MB group (P <0.0001), while smoking was more common (18.76% vs 16.87%, P <0.01).

CONCLUSIONS Patients with MB were younger and had fewer comorbidities and risk factors for atherosclerosis than patients without MB. The condition was more common among patients with stable coronary artery disease. Smoking and female sex appeared to be associated with a more clinically symptomatic presentation of MB.

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INTRODUCTION Myocardial bridges (MBs) were first described by Reyman in 1737[1] and then by Geiringer in an autopsy series in 1951.[2] The first characterization of MBs in modern literature included not only a description of their morphology, but also a remark that an altered course of coronary arteries might affect the progression of atherosclerosis.[2] Since

WHAT'S NEW?

The aim of the study was to evaluate the prevalence and clinical presentation of a myocardial bridge (MB) in coronary arteries among patients diagnosed using coronary angiography in Poland. The study included 298 558 patients. Patients with MB were younger and had fewer comorbidities and risk factors for atherosclerosis than patients without MB. The most frequent location of MB was the left anterior descending artery, and MB was more common in patients with stable coronary artery disease. In the case of acute coronary syndromes, only unstable angina was more frequent in the MB group. Smoking and female sex appeared to be associated with more clinically symptomatic presentation of MB. Therefore, smoking cessation may reduce or help avoid angina symptoms in these patients.

then, our knowledge and understanding of the pathophysiology, occurrence, diagnostics, and possible treatment methods of MBs have significantly improved.

An MB is defined as a congenital anomaly, where a segment of an epicardial coronary artery takes an intramuscular course and returns to the epicardium distal to the bridged section.[3-5] Myocardial bridges are included in class I of the clinical classification of rare cardiovascular diseases and disorders.[6,7] The occurrence of an MB indicates the presence of the myocardium overlying the coronary artery, which causes the narrowing of the artery during each heart contraction.[5,8] According to most opinions based on observations, an MB is a benign, normal anatomical variant without pathologic implications.[8] Nevertheless, the presence of an MB can lead to ischemia, which can be demonstrated by ultrasound. An MB can also result in delayed relaxation during the early diastolic phase, which is the period of maximal coronary blood flow.[9-11] These changes lead to impaired coronary vasodilator reserve due to delayed blood flow and reduced distal coronary pressure. Moreover, an MB compresses the affected segment and leads to increased blood flow velocity during systole and diastole. The probability of ischemia also increases in cases of proximally located MBs, longer affected segments, and deeper locations.[8,9]

The mechanism of ischemia is linked not only with systolic obstruction, but also with shortening of the diastolic phase in tachycardia with impaired diastolic filling. This relationship has been demonstrated via tests using dobutamine or rapid atrial pacing.[3] Another mechanism of ischemia is the development of atherosclerosis in the presence of MBs. Pathologic studies have revealed that bridged segments of the coronary artery are relatively less affected, while in segments proximal to the bridge atherosclerosis develops more rapidly. This is the result of shear stress having a different impact in the proximal and tunneled sector of an artery, but also from changes of endothelial cell function and morphology. All these mechanisms can lead to symptoms such as exertional chest pain or dyspnea, coronary spasm, acute coronary syndromes (ACSs), left ventricular dysfunction, arrhythmias, and even sudden cardiac death.[3,4]

The prevalence of MBs varies among studies. The rates reported in autopsy series range from 4.7% to 60% (mean, 25%) and are much higher than those obtained in angiographic studies, which report MBs in 0.5% to 12% of cases.[12] The prevalence rates increase to 40% when a positive inotropic medication is used as a provocative agent.[13]

Myocardial bridges can be detected using several available diagnostic techniques such as single-photon emission computed tomography, cardiac computed tomography, magnetic resonance imaging, and coronary angiography.[4,9] However, coronary angiography as a stand-alone technique is not considered to be sufficiently sensitive, and using this procedure alone would not allow us to exclude the presence of an MB.[4] Other intravascular techniques can also be useful in the diagnosis, such as intravascular ultrasound and fractional flow reserve. Intravascular ultrasound reveals the pathognomonic half-moon sign and offers a higher diagnostic value.[14-16]

The aim of this study was to evaluate the prevalence of MBs in coronary arteries among patients hospitalized between January 1, 2014, and December 31, 2016, in invasive cardiology departments in Poland, who were diagnosed using coronary angiography. Our goal was to assess the prevalence of MBs among patients admitted to hospitals with various clinical presentations such as stable angina, ACSs (unstable angina, non–ST-segment elevation myocardial infarction [NSTEMI], ST-segment elevation myocardial infarction [STEMI]), cardiac arrest, congenital heart disease, and others. Moreover, we sought to compare the presence of comorbidities, including risk factors for atherosclerosis and other clinical states, between patients with or without MBs.

METHODS Data were obtained from the National Polish Percutaneous Interventions Registry (*Ogólnopolski Rejestr Procedur Kardiologii Inwazyjnej* [ORPKI]), among patients hospitalized between January 1, 2014, and December 31, 2016, in invasive cardiology departments in Poland. The ORPKI is a national registry collecting data from all percutaneous interventional cardiology procedures performed in Poland. The study population was divided into 2 groups: with or without an MB.[17]

The presence of an MB was assessed by cardiologists during coronary angiography. Data on comorbidities were obtained from medical history. During the study, no additional laboratory tests were performed and no intravascular

imaging was used for the assessment of proximal plaque formation. Collected data were analyzed and descriptive statistics were performed in each group of patients.

The analyzed database contains data on patients admitted to hospitals to undergo coronary angiography. The database includes the number of admissions instead of the number of patients. Hence, one patient could be included in the database several times but such information would not be present in the database. The analyses did not consider patient clustering; however, the number of records is several orders of magnitude higher than the number of clustered records, and one patient could have been admitted several times. Most patients are expected to have been admitted only once. Because of this, the clustering effect should be negligible.

Nominal variables were presented as numbers (percentages) and compared using the likelihood ratio test, while continuous variables were presented as means (SD) and compared using the *t* test. *P* values of less than 0.05 were assumed to indicate significance; however, clinical significance of the results should be interpreted with respect to expert knowledge of a particular parameter. The analyses were conducted using the JMP® 14.0.0 software (SAS Institute Inc., Cary, North Carolina, United States). To avoid potential influence of the nonrandomized design, a propensity score was calculated using a multivariate logistic regression model with the presence of MB as the dependent variable, and sex, age, and indication set as covariates. The pairs of patients with and without MB were formed using 1:1 nearest neighbor matching. For paired data samples, where the measurement was performed on an interval or a ratio scale and 2 variables were compared, the paired *t* test was used if the differences between pairs were normally distributed (the Kolmogorov–Smirnov–Lilliefors test was used to determine if a sample came from a normally distributed population); otherwise, the Wilcoxon signed-rank test was used. For nominal variables, the McNemar or Bowker test was used.

RESULTS Our study included 298 558 patients. In the non-MB group, there were 296 133 patients (99.19%; 111 243 women [38.01%]), and in the MB group, there were 2425 patients (0.81%; 969 women [39.98%]). The mean (SD) age of patients in the non-MB group was 66.61 (10.85) years (range, 15–105 years) and was higher than in the MB group (mean [SD], 63.20 [11.04]; range, 18–95 years; P <0.0001). Patients in the MB group also had higher weight than patients in the non-MB group (80.64 kg and 79.92 kg, respectively, P = 0.03). The study group included 112 212 women (37.58%) and 182 873 men (61.25%). Data on sex were lacking for 3473 patients (1.16%). An MB was present in 969 women (39.98%) and 1455 men (60.02%). Regarding prevalence in the whole study group, MBs were slightly more frequent among women than among men (0.86% vs 0.80%, P = 0.048).

The most frequent location of an MB was the left anterior descending artery (2355 patients; 0.79% of the whole study group and 97.11% of the MB group). An MB at the circumflex artery was relatively rare (40 patients; 0.013% of the whole study group and 1.65% of the MB group). The least common location of an MB was the right coronary artery (18 patients; 0.006% of the whole study group and 0.74% of the MB group).

Among all patients, 885 (0.3% of the whole study group) died during the procedure in a catheterization laboratory. Two patients with MBs died (0.08% of the whole study group), and the mortality rate was lower in the MB group than in the non-MB group (883 patients; 0.3% of the whole study group; P = 0.056).

We also assessed the prevalence of comorbidities such as hypertension, diabetes, previous stroke, previous myocardial infarction, presence of kidney disease, chronic obstructive pulmonary disease, psoriasis (TABLE 1), as well as other clinical data such as previous percutaneous coronary intervention (PCI), previous coronary artery bypass graft (CABG), and smoking status (TABLE 2). Interestingly, patients in the MB group less often had diabetes (14.68% vs 21.63%), previous stroke (1.61% vs 2.96%), previous myocardial infarction (10.97% vs 21.97%), kidney disease (2.8% vs 5.04%), previous CABG (1.03% vs 5.64%), or previous PCI (13.20% vs 25.86%) than those in the non-MB group (all comparisons, P <0.0001). The prevalence of hypertension was slightly higher in the MB group, but the difference was not significant. The prevalence of MBs was also higher in smokers compared with nonsmokers (18.76% vs 16.87%, P <0.01). The propensity score assessment confirmed previous results assessed both in the MB and non-MB groups (TABLES 1 and 3).

More than half of the study group had ACS (171 112 patients [57.31%]), and an MB was present in 1258 patients (0.74% of the whole study group; 51.88% of the MB group), which was lower than in patients admitted due to ACS and without MB (57.36%, P <0.0001). Stable coronary artery disease was present in 111 241 patients (37.26%), of whom 1066 had MB (0.96% of the whole study group; 43.96% of the MB group). Myocardial bridges were more common among patients with stable angina than in those with ACS (43.96% vs 37.20%, respectively, P <0.0001). Interestingly, the analysis of unstable angina, NSTEMI, and STEMI separately revealed that MBs were more frequent in patients with unstable angina (36% vs 32.70%) and less frequent in those with NSTEMI (7.67% vs

TABLE 1 Comorbidities and clinical presentations in patients with and without myocardial bridge

	Total number of patients	Non-MB group	MB group	*P* value
Diabetes	64 403 (21.57)	64 047 (21.63)	356 (14.68)	<0.0001
Previous stroke	8796 (2.95)	8757 (2.96)	39 (1.61)	<0.0001
Previous myocardial infarction	65 322 (21.88)	65 056 (21.97)	266 (10.97)	<0.0001
Psoriasis	1080 (0.36)	1074 (0.36)	6 (0.25)	0.49
Hypertension	205 703 (68.90)	204 017 (68.89)	1686 (69.53)	0.50
Kidney disease	14 979 (5.02)	14 911 (5.04)	68 (2.80)	<0.0001
Chronic obstructive pulmonary disease	7977 (2.67)	7918 (2.67)	59 (2.43)	0.46
Stable angina	111 241 (37.26)	110 175 (37.20)	1066 (43.96)	<0.0001
Unstable angina	97 719 (32.73)	96 846 (32.70)	873 (36.00)	
NSTEMI	38 917 (13.03)	38 731 (13.08)	186 (7.67)	
STEMI	34 476 (11.55)	34 277 (11.57)	199 (8.21)	
Cardiac arrest	1734 (0.58)	1725 (0.58)	9 (0.37)	
Congenital heart disease	8546 (2.87)	8500 (2.87)	46 (1.90)	
Other	5924 (1.98)	5878 (1.98)	46 (1.90)	

Data are presented as number (percentage). *P* values of less than 0.05 were significant.

Abbreviations: MB, myocardial bridge; NSTEMI, non–ST-segment elevation myocardial infarction; STEMI, ST-segment elevation myocardial infarction

TABLE 2 Occurrence of other clinical conditions in patients with and without myocardial bridge

	Total number of patients	Non-MB group	MB group	*P* value
Cigarette smoking	50 398 (16.88)	49 943 (16.87)	455 (18.76)	0.01
Previous CABG	16 740 (5.61)	16 715 (5.64)	25 (1.03)	<0.0001
Previous PCI	76 892 (25.75)	76 572 (25.86)	320 (13.20)	<0.0001

Data are presented as number (percentage). *P* values of less than 0.05 were significant.

Abbreviations: CABG, coronary artery bypass grafting; PCI, percutaneous coronary intervention; others, see TABLE 1

TABLE 3 Comorbidities and clinical presentations assessed in propensity score in patients with and without myocardial bridge

	Non-MB group	MB group	*P* value
Diabetes	513 (21.15)	356 (14.68)	<0.0001
Previous stroke	64 (2.64)	39 (1.61)	0.01
Previous myocardial infarction	406 (16.74)	266 (10.97)	<0.0001
Psoriasis	5 (0.21)	6 (0.25)	0.76
Hypertension	1668 (68.78)	1686 (69.53)	0.57
Kidney disease	133 (5.48)	68 (2.80)	<0.0001
Chronic obstructive pulmonary disease	79 (3.26)	59 (2.43)	0.08

Data are presented as number (percentage). *P* values of less than 0.05 were significant.

Total number of matched pairs: 2500.

Abbreviations: see TABLE 2

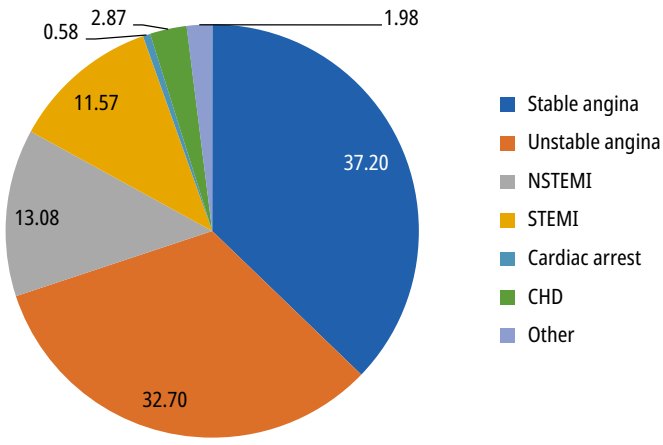

FIGURE 1 Percentage of clinical indications for coronary angiography in patients without myocardial bridge (*P* <0.0001)
Abbreviations: CHD, coronary heart disease; others, see TABLE 1

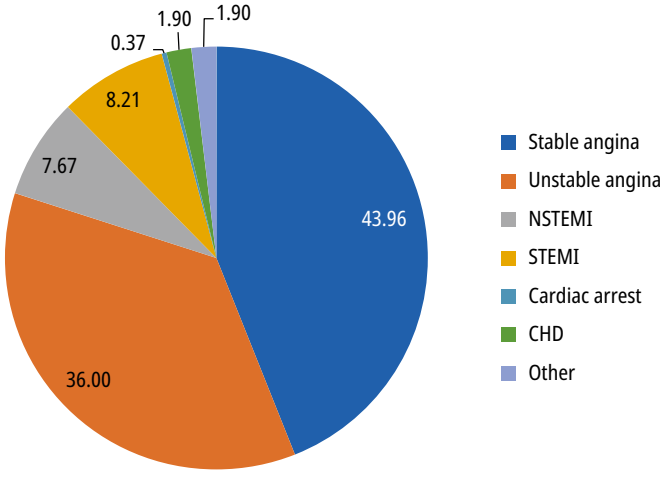

FIGURE 2 Percentage of clinical indications for coronary angiography in patients with myocardial bridge (*P* <0.0001).
Abbreviations: see TABLE 1 and FIGURE 1

TABLE 4 **Occurrence of other clinical conditions assessed in propensity score in patients with and without myocardial bridge**

	Non-MB group	MB group	*P* value
Cigarette smoking	309 (12.74)	455 (18.76)	<0.0001
Previous CABG	116 (4.78)	25 (1.03)	<0.0001
Previous PCI	445 (18.35)	320 (13.20)	<0.0001

Data are presented as number (percentage). *P* values of less than 0.05 were significant.

Total number of matched pairs: 2500.

Abbreviations: see TABLE 2

13.08%) and STEMI (8.21% vs 11.57%; *P* <0.0001) (FIGURE 1 and 2). The prevalence of MBs was also lower in patients admitted due to cardiac arrest, congenital heart defect, and other conditions (TABLE 4).

The presence of atherosclerotic plaque proximal to the segment of the vessel with MB was low, with 83 records in the MB group (3.42%).

DISCUSSION

The presence of clinical symptoms and suspicion of ischemia is, in many cases, an indication for coronary angiography, especially in younger patients with fewer comorbidities and a higher prevalence of MBs in stable coronary artery disease. Regarding risk factors in our study, the incidence of hypertension and diabetes was higher among patients with an MB than that reported by Çay et al.[18] The higher incidence of MBs among smokers might be associated with the fact that smoking provokes a coronary artery spasm,[19] thereby triggering symptoms which lead to diagnostic workup. The analysis of atherosclerotic risk factors such as diabetes, hypertension, male sex, and smoking has not provided any clear conclusions. Further studies regarding risk factors for atherosclerosis and the presence of atherosclerosis among patients with MBs are needed.

The prevalence of MBs in our study group (0.81%) is in line with the rates presented in other reports. Noble et al[20] revealed a prevalence of 0.51%, while Juilliére et al,[21] in a study involving 7467 consecutive patients, showed an overall prevalence of 0.82%. In one of the largest retrospective studies conducted in Turkey by Çay et al,[18] which included 25 982 patients, the prevalence of MBs was 1.22% and the left anterior descending artery was affected in 96.52% of cases. Myocardial bridges located at the circumflex artery and right coronary artery have been rarely reported.[18,19,22,23]

The relatively large differences in the prevalence rates of MBs between angiographic and autopsy reports, as mentioned previously, can be explained by several factors. Using angiography, we can visualize MBs thicker than 200 µm. Additionally, severe atherosclerotic lesions located proximally to the MB may conceal its presence because of a drop in coronary flow to the distal part of an artery, thereby masking the distinctive "milking effect."[12] Moreover, there is a large disparity in a sample size between angiographic and autopsy reports, with the latter being comparatively smaller.[12] A low frequency of proximal atherosclerotic plaque in the MB group might reflect a lower frequency of comorbidities in these patients compared with the non-MB group.

Study limitations

The most important limitation of the present study is its retrospective design. Data were submitted by all interventional centers in Poland, with a different grade

of completeness. All data regarding comorbidities were based on medical records, and there were no additional laboratory tests or long-term follow-up during data collection. Coronary angiograms were not assessed directly, but written descriptions were analyzed. Additionally, cardiologists performing coronary angiography were not specifically trained in the assessment of MBs, and some minor MBs could have been overlooked.

Conclusions Compared with the non-MB group, patients with MBs diagnosed by angiography were younger and had fewer comorbidities and risk factors for atherosclerosis such as diabetes, previous stroke, previous myocardial infarction, kidney disease, previous CABG, and previous PCI. Myocardial bridges were more common among patients with stable coronary artery disease. The frequency of proximal atherosclerotic plaque was low in the MB group. Smoking and female sex were associated with more clinically symptomatic presentation of MB. Further studies are needed to establish the role of classic risk factors in patients with MB.

ARTICLE INFORMATION

CONFLICT OF INTEREST None declared.

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