Relationship Between the Length and Depth of Myocardial Bridging and the Degree of Proximal Coronary Artery Stenosis Using Coronary Computed Tomography Angiography

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Abstract

Background:

Myocardial bridging (MB) is a congenital anomaly of the coronary arteries that results in dynamic compression during the cardiac cycle. This condition accelerates the development of atherosclerosis, particularly in the proximal coronary segment. Evidence regarding the relationship between MB morphology and the degree of stenosis based on coronary CT angiography (CCTA) remains limited and inconsistent. This study aimed to evaluate the association between MB length and depth and the degree of proximal coronary artery stenosis using CCTA at Siloam Lippo Village Hospital.

Methods:

This was an observational analytic study with a cross-sectional design. Samples were obtained through consecutive sampling of patients aged ≥18 years who underwent CCTA between 2024 and 2025. Data were analysed using the Mann-Whitney U test for comparison of means, with a p-value <0.05 considered statistically significant.

Result:

A total of 144 patients met the inclusion criteria. MB was most commonly found in the mid-left anterior descending (mid-LAD) segment, with a mean depth of 1.18 mm and a mean length of 14.67 mm. Most proximal stenosis cases were categorized as non-significant (<50%). Mann-Whitney U analysis showed that MB depth was significantly associated with the degree of proximal stenosis ($p = 0.006$), whereas MB length was not ($p = 0.345$). The interaction between these variables, represented as MB area, showed a stronger correlation with the degree of stenosis ($p = 0.004$).

Conclusion:

MB is associated with the degree of proximal coronary artery stenosis as assessed by CCTA. These findings may improve risk stratification and support more appropriate clinical management in patients with MB.

Introduction

Myocardial bridging (MB) is a congenital anomaly of the coronary arteries in which a segment of the artery courses intramyocardially, forming a "bridge" over the myocardium.[1] This condition may occur in all epicardial coronary arteries, but it is most frequently found in the left anterior descending (LAD) artery, particularly in the proximal and mid-LAD segments. The prevalence of MB varies according to the diagnostic method, ranging from 2–6% on coronary angiography (CA), 19–22% on CCTA, and reaching >30% in autopsy studies.[2,3]

Unlike atherosclerotic plaque, which produces fixed stenosis, MB causes dynamic stenosis influenced by the cardiac cycle, heart rate, and sympathetic tone. The clinical manifestations of MB vary widely, ranging from mild conditions to severe presentations such as myocardial ischemia, arrhythmia, and sudden cardiac death. The depth of the tunneled artery determines the severity of coronary compression. MB is classified as superficial (1–2 mm) and deep (>2 mm). In certain cases, MB may also be considered long (>25 mm) or very deep (>5 mm). Superficial MB tends to be asymptomatic, whereas deep or long MB may be symptomatic.[2,4]

The diagnosis of MB requires a combination of history taking, physical examination, and appropriate radiologic evaluation. With advances in technology, particularly multi-detector computed tomography (MDCT), accurate non-invasive evaluation has become possible to visualize the coronary lumen, assess the presence of atherosclerosis, and detect MB. CT angiography has become an important tool for analyzing coronary anatomy and flow patency. Studies using CT angiography to evaluate MB are able to detect intramyocardial segments at a much higher rate than conventional angiography. The fundamental finding in MB is an epicardial coronary artery that courses into the myocardium, with myocardial contractility affecting the tunneled artery during both systolic and diastolic phases. Although only a small proportion of MB cases are symptomatic, inadequate management may lead to significant morbidity and mortality. CT angiography offers relatively high diagnostic accuracy and is non-invasive.[5-7]

Nevertheless, studies evaluating the relationship between MB morphology (length and depth) and the degree of proximal coronary artery stenosis remain limited and have shown inconsistent results, especially in Indonesia. Therefore, this study was conducted to evaluate this relationship using coronary CT angiography at Siloam Lippo Village Hospital, Tangerang.

Material And Methods

This research used an observational analytic study with a cross-sectional approach and was conducted in 2025 at the Radiology Department of Siloam Lippo Village Hospital, Tangerang. Samples were collected using a consecutive sampling technique. The target population consisted of all individuals undergoing CT angiography in Tangerang, whereas the accessible population comprised all individuals undergoing coronary CT angiography at the Radiology Department of Siloam Lippo Village Hospital, either for medical check-up (MCU) purposes or based on clinician referral. The inclusion criteria were patients aged ≥18 years who underwent coronary CT angiography with adequate documentation allowing identification and measurement of MB (depth, location, and segment length). The exclusion criteria were patients with other cardiac or coronary artery anatomical abnormalities, as well as imaging studies with suboptimal quality that did not permit accurate measurement of MB depth and the degree of stenosis. Data were obtained from the Infinitt PACS system and medical records from January 2024 to December 2025, including MB depth, MB length, and the degree of proximal stenosis.

Data analysis was performed using SPSS version 26. Univariate analysis was used to describe variable characteristics, with normality assessed by the

Kolmogorov-Smirnov test. Bivariate analysis was carried out to compare numeric MB length and depth between significant and non-significant stenosis groups. The Mann-Whitney U test was used because the data were not normally distributed, while the chi-square test or Fisher's exact test was applied for categorical variables as appropriate. Multivariate analysis was then performed using logistic regression to control for confounding variables such as age, sex, hypertension, diabetes mellitus, dyslipidemia, and smoking history, with $p<0.05$ considered statistically significant. All data underwent editing, coding, entry, cleaning, and analysis. This study had received ethical approval and ensured the confidentiality of patient identities.

Result

Data were collected from January 2024 to December 2025 at Siloam Hospital Tangerang, with a total of 144 patients with MB included in the study. The sex distribution was dominated by males, with 86 patients (59.7%), while females accounted for 58 patients (40.3%). Age was normally distributed, with a mean age of 54.86 ± 10.49 years. Among all patients with MB, 46 (31.9%) had stenosis ≥50%, and the most frequent MB location was the mid-LAD in 91 patients (63.2%). Risk factors included hypertension (43.8%), diabetes mellitus (24.3%), and dyslipidemia (47.9%). The demographic data of the study subjects are shown in Table 1 below.

Table 1. Demographic Characteristics of the Study Subjects

Variable	N (%) or Median (IQR) or Mean ± SD	Kolmogorov-Smirnov Normality Test
Sex	86 (59.7%)	
Male	58 (40.3%)	
Female		
Age (years)	54.86 ± 10.49	0.200
Location of Stenosis	35 (24.3%)	
Proximal LAD	91 (63.2%)	
Mid LAD	1 (0.7%)	
D1	17 (11.8%)	
No stenosis		
Degree of Stenosis	46 (31.9%)	
Significant	98 (68.1%)	
Non-significant		
Hypertension	63 (43.8%)	
Diabetes Mellitus	35 (24.3%)	
Dyslipidemia	69 (47.9%)	
Calcium Score	1.90 (139.00)	< 0.005
MB Length (mm)	14.67 (15.11)	< 0.005
MB Depth (mm)	1.18 (2.03)	< 0.005

These data were then compared bivariately against the study outcome, namely the degree of stenosis, to determine the effect of each variable on stenosis severity. Bivariate analysis showed that males had a 2.51-fold higher risk of significant stenosis compared with females ($p = 0.017$). Age also differed significantly between the significant and non-significant stenosis groups, with the significant stenosis group being older on average ($p = 0.005$). All risk factors in this study showed significant p-values ($p<0.05$) in relation to stenosis severity, namely hypertension ($p = 0.001$), diabetes mellitus ($p = 0.015$), and dyslipidemia ($p = 0.004$), with corresponding odds ratios of 3.21, 2.61, and 2.84. The results of the bivariate analysis are shown in Table 2 below. All variables that were significant in the bivariate analysis were subsequently entered into multivariate analysis to control for bias, whereas stenosis location was not included.

Table 2. Bivariate Analysis of Study Variables in Relation to the Degree of Stenosis

Variable	Significant (n = 46)	Non-significant (n = 98)	Odds Ratio (95% CI)	p-value
Age	58.65 ± 10.38	53.50 ± 10.13	-	0.005
Sex	34 (39.5%)	52 (60.5%)	2.51	0.017
Male	12 (20.7%)	46 (79.3%)	(1.16 – 5.41)	
Female				
Location of Stenosis	17 (48.6%)	18 (51.4%)	-	0.001
Proximal LAD	28 (30.8%)	63 (69.2%)		
Mid LAD	1 (100.0%)	0 (0.0%)		
D1	0 (0.0%)	17 (100.0%)		
No stenosis				
Hypertension	29 (46.0%)	34 (54.0%)	3.21	0.001
Yes	17 (21.0%)	64 (79.0%)	(1.55 – 6.66)	
No				
Diabetes Mellitus	17 (48.6%)	18 (51.4%)	2.61	0.015
Yes	29 (26.6%)	80 (73.4%)	(1.19 – 5.73)	
No				
Dyslipidemia	30 (43.5%)	39 (56.5%)	2.84	0.004
Yes	16 (21.3%)	59 (78.7%)	(1.37 – 5.88)	
No				
Calcium Score	531.53 ± 771.63	37.37 ± 77.98	-	< 0.005
MB Length (mm)	17.34 ± 9.88	15.92 ± 10.16	-	0.345
MB Depth (mm)	2.14 ± 2.03	1.46 ± 2.85	-	0.006
MB Area (mm²)	44.98 ± 54.59	21.29 ± 32.00	-	0.004

In the comparison of means, calcium score, MB depth, and MB area were significantly different according to the degree of stenosis. However, MB length showed a p-value > 0.05, indicating no statistically significant difference according to stenosis severity. For calcium score, the significant stenosis group had a higher mean value of 531.53 ± 771.63, whereas the non-significant group had a mean of 37.37 ± 77.98. Meanwhile, MB length showed no statistically significant difference between the significant and non-significant stenosis groups, with mean values of 17.34 ± 9.88 and 15.92 ± 10.16, respectively.

Table 3. Categorical Analysis of MB Length and Depth in Relation to the Degree of Stenosis

MB Category	Non-significant	Significant	Odds Ratio (95% CI)	p-value
Not Long + Not Deep	67 (75.3%)	22 (24.7%)	Ref.	0.007
Long	10 (62.5%)	6 (37.5%)	1.83 (0.59 – 5.61)	
Deep	17 (60.7%)	11 (39.3%)	1.97 (0.80 – 4.84)	
Long + Deep	4 (36.4%)	7 (63.6%)	5.33 (1.42 – 19.94)	

Categorical analysis was also performed to better understand the effect of myocardial bridging on the degree of stenosis. This analysis showed a significant relationship between MB and stenosis severity, with p = 0.007. As shown in Table 3 above, a long MB increased the risk of significant stenosis by 1.83 times compared with MB that was neither long nor deep. Patients with deep MB also had a higher odds ratio of 1.97 (95% CI: 0.80 – 4.84). The highest risk was observed in patients with both long and deep MB, who had a 5.33-fold higher risk of significant stenosis compared with the group whose MB was neither long nor deep.

The collected data for calcium score, MB length, MB depth, and MB area were all non-normally distributed. Therefore, Spearman correlation was used to determine the numerical relationship between these variables. Bivariate analysis using Spearman correlation showed a significant correlation between calcium score and MB depth as well as MB area, but not MB length. MB length had an r value of 0.092 with p = 0.292. MB depth had an r value of 0.251 with p = 0.004, and MB area had an r value of

0.268 with p = 0.002. Although these correlations were not strong, the significant p-values indicate a relationship between calcium score and MB depth as well as MB area, but not MB length.

Table 4. Multivariate Analysis of the Degree of Stenosis

Variable	Exp(B) (95% CI)	p-value
Age	0.99 (0.94 – 1.04)	0.723
Male Sex	1.26 (0.47 – 3.40)	0.646
Hypertension	1.86 (0.71 – 4.85)	0.207
DM	1.07 (0.36 – 3.19)	0.902
Dyslipidemia	1.67 (0.63 – 4.42)	0.298
Calcium Score	1.01 (1.00 – 1.01)	0.011
MB Area	1.01 (0.99 – 1.02)	0.082
Constant	0.13	0.153

Logistic regression analysis showed that only the calcium score variable remained statistically significant ($p = 0.011$). The multivariate model yielded a Nagelkerke R square of 0.426, indicating that the model had a predictive ability of 42.6% for severe stenosis. The Hosmer and Lemeshow test produced a value of 0.052, which was not statistically significant, indicating that the model fit the observed data reasonably well. Although the predictive performance was not yet optimal, these findings can serve as an initial basis for future studies with a broader range of variables and a larger sample size.

Discussion

Previous studies have consistently shown that MB increases the risk of coronary artery stenosis and major adverse cardiac events (MACE). The increase in cardiovascular risk among patients with MB has been reported to be 1.5- to 5-fold higher than in patients without MB.8-10 A study by Yang et al. in 2024 also showed that patients with MB had a hazard ratio of 1.57 (95% CI: 1.44 – 1.72) for the development of coronary artery disease.11 Nakaura et al. performed a multivariate analysis showing that age, diabetes mellitus, and MB in the mid-LAD were statistically significantly associated with proximal LAD atherosclerosis ($p < 0.05$).5 The findings of the present study are in line with previous studies and reinforce the conclusion that MB is closely associated with atherosclerosis.

This study also demonstrated a statistically significant association between MB and CAC values. This is similar to the findings of Nafakhi et al. in 2019, which showed that MB length was not associated with CAC ($r = 0.0$; $p = 0.9$). In contrast, MB depth was associated with CAC ($r = 0.4$; $p = 0.006$). That study also found no significant difference in mean MB length between patients with stenosis ≥ 50% and patients without stenosis, with means of 21 ± 10 mm in those without stenosis and 21 ± 8 mm in those with stenosis ≥ 50%. Meanwhile, MB depth differed significantly, with a mean of 3 ± 1.1 mm in patients without stenosis and 4.4 ± 2 mm in those with stenosis ≥ 50% ($p = 0.03$).12

Thus, it can be concluded that MB morphology may influence the degree of stenosis after controlling for sex, age, hypertension, diabetes mellitus, dyslipidemia, and CAC. This is supported by the result that MB area, which represents the interaction between MB length and depth, had a p-value of 0.004 in relation to the degree of stenosis in the Mann-Whitney U analysis. Although the multivariate analysis yielded a p-value of 0.082 with an exp(B) of 1.01, this finding may serve as an initial basis for future studies analyzing the relationship between MB and the degree of stenosis.

However, this study has several limitations. It was conducted at a single center, thereby limiting population representativeness. The variables analyzed were also limited and did not include other risk factors such as smoking, physical activity, past medical history, and ongoing therapy. In addition, although the sample size was adequate, the lack of an association between MB length and stenosis still requires confirmation through studies with larger samples and multicenter designs.

Conclusions

This study showed that patients with myocardial bridging (MB) were predominantly male (59.7%) with a mean age of 54.86 ± 10.49 years. The main risk factors were hypertension (43.8%), dyslipidemia (47.9%), and diabetes mellitus (24.3%). Of the 144 patients, 31.9% had significant coronary stenosis (≥50%). Morphologically, MB length was not associated with the degree of stenosis, whereas MB depth and MB area showed significant associations. MB area appeared to be more representative in predicting stenosis than a single parameter alone. In addition, MB depth and MB area correlated with the calcium score, although the strength of the correlation was weak. In multivariate analysis, only calcium score remained significant in relation to stenosis, but MB area still showed potential as a clinical indicator. The model had a predictive ability of 42.6%.

These findings suggest that MB plays a role in increasing the risk of coronary stenosis. Therefore, MB morphological parameters may be used in clinical practice for risk stratification, earlier screening, and patient education related to the prevention of heart disease.

For future studies, it is recommended to involve a larger sample size, use a multicenter design, and include additional variables such as smoking, physical activity, past medical history, and therapy. Prospective designs and further analyses such as ROC analysis are also needed to improve predictive accuracy and evaluate the potential use of MB as a clinical screening tool.

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