JACC: CASE REPORTS VOL. 30, NO. 32, 2025

ISCHEMIC HEART DISEASE

THE FOUR CORNERS: "DA VINCI" ANATOMY CORNER

Fundamental Anatomy and Its Impact on Clinical Practice

Myocardial Bridging

Rodrigo Ortega-Pérez, MD, PhD,[a,b] Borja Ibañez, MD, PhD,[b,c,d] Damián Sánchez-Quintana, MD, PhD,[e] José-Ángel Cabrera, MD, PhD[a,d]

STRUCTURAL PERSPECTIVES ON MYOCARDIAL BRIDGING

Myocardial bridging (MB) is a congenital anatomic anomaly in which a segment of a coronary artery courses intramyocardially rather than following an epicardial course.[1] The muscle overlying the artery is termed a "myocardial bridge," and the intramyocardial segment of the artery is referred to as a "tunneled artery" (Video 1, **Figure 1**). Noninvasive imaging techniques have brought greater attention to this finding, previously underestimated in invasive coronary angiography studies and now recognized in 1 out of 5 individuals. It primarily affects the left anterior descending artery (LAD) (most commonly the proximal and mid segments) but—as clearly demonstrated by the anatomical dissections illustrated through the video and images—coronary segments across multiple regions of the heart may also be involved (**Figure 2**). Anatomical factors such as the depth, length, and orientation of the tunneled segment, as well as the thickness and contractile nature of the overlaying myocardial fibers, directly influence the extent of systolic compression and its hemodynamic consequences. Bridging involving long or deep intramyocardial segments, particularly those affecting the mid to distal LAD, is more likely to be symptomatic, especially during conditions of increased myocardial demand, and this may influence the choice of therapeutic approach. The deeper and longer the myocardial bridge, the stronger the association with ischemia. Deep myocardial bridges are defined as those with more than 2 mm of overlying myocardium, and very deep bridges are characterized by more than 5 mm. A long myocardial bridge is defined as having more than 25 mm of overlying myocardium.

TAKE-HOME MESSAGES

- The hemodynamic impact of MB is determined by specific anatomical features of the tunneled segment, including its depth (>2 mm for deep bridges, >5 mm for very deep), length (>25 mm), and location, with the mid to distal left anterior descending artery most commonly and severely affected.
- Although MB has traditionally been viewed as a benign variant, it can lead to significant ischemia, arrhythmias, or even sudden cardiac death, particularly under increased cardiac demand. Accurate anatomical and functional assessment is essential for diagnosis and individualized management.

From the [a]Cardiology Department, Hospital Universitario QuirónSalud, European University of Madrid, Madrid, Spain; [b]Centro Nacional de Investigaciones Cardiovasculares (CNIC), Madrid, Spain; [c]Hospital Universitario Fundación Jiménez Díaz (IISFJD, UAM), Madrid, Spain; [d]Ciber de Enfermedades Cardiovasculares (CIBERCV), Madrid, Spain; and the [e]Department of Human Anatomy, Faculty of Medicine, Badajoz, Spain.

The authors attest they are in compliance with human studies committees and animal welfare regulations of the authors' institutions and Food and Drug Administration guidelines, including patient consent where appropriate. For more information, visit the Author Center.

Manuscript received June 2, 2025; revised manuscript received July 11, 2025, accepted July 20, 2025.

ISSN 2666-0849 https://doi.org/10.1016/j.jaccas.2025.105096

JACC: CASE REPORTS, VOL. 30, NO. 32, 2025
OCTOBER 15, 2025:105096

ABBREVIATIONS AND ACRONYMS

LAD = left anterior descending artery

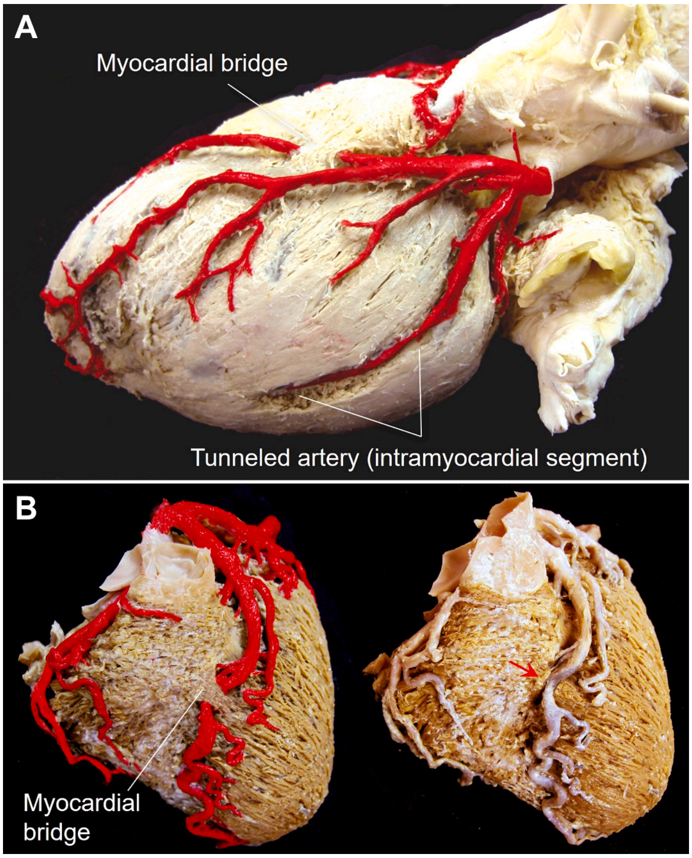
MB = myocardial bridging

FROM BENCH TO BEDSIDE: GUEST INSIGHT ON CLINICAL IMPACT

Although MB is often regarded as a benign anatomical variant, increasing clinical evidence has revealed its potential to cause ischemic symptoms, particularly in patients with specific anatomical factors as outlined above, including the depth, length, and location of the myocardial bridge, along with physiological characteristics such as heart rate, myocardial contractility, and coronary vasoreactivity. Understanding the precise anatomy of MB is essential for interpreting its clinical significance. As previously stated, MB most commonly affects the mid LAD, and it can lead to dynamic, flow-limiting compression of the tunneled arterial segment, especially under conditions of increased heart rate and contractile force.[1]

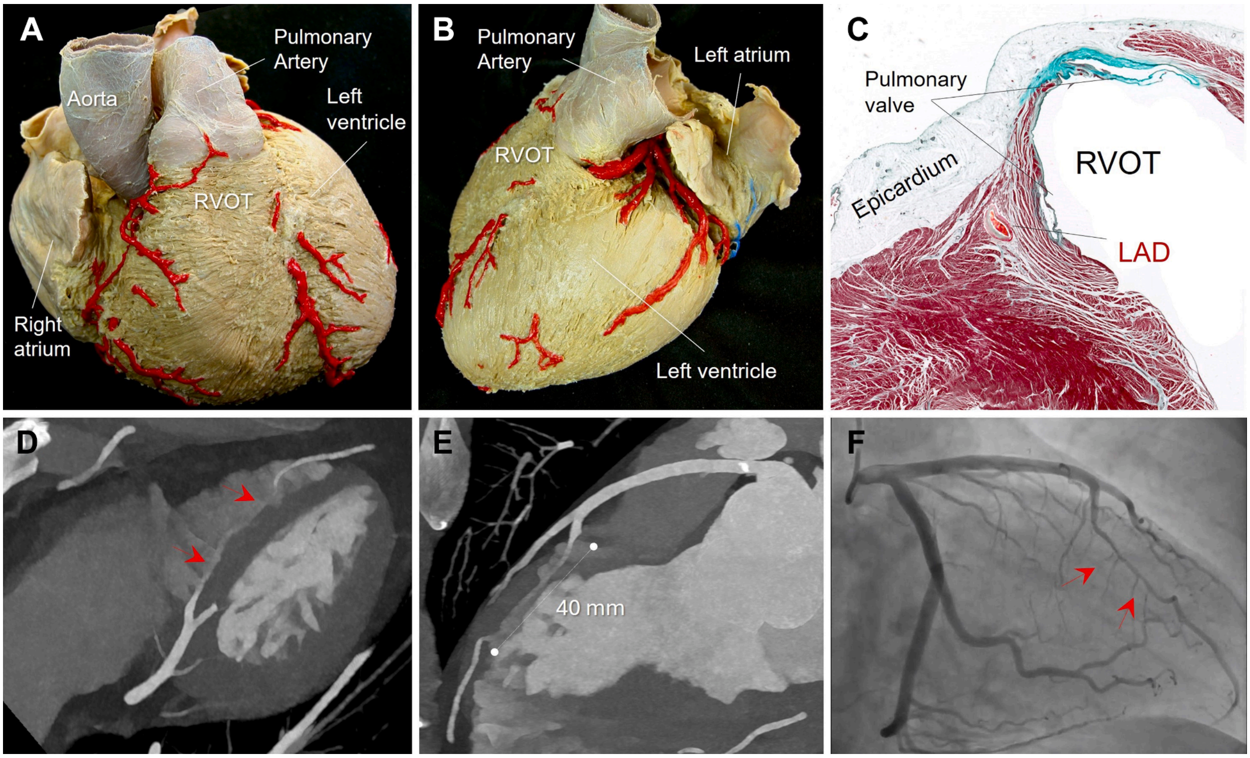
Clinical presentation in patients with MB include exertional angina, dyspnea, arrhythmias, or syncope. In some cases, MB has been implicated in acute coronary syndromes with nonobstructive coronary arteries, stress cardiomyopathy, and even sudden cardiac death, particularly in young individuals or athletes. The variability in symptom expression underscores the need for careful clinical assessment, particularly in patients with persistent chest pain and nonobstructive coronary angiography findings.

FIGURE 1 **Anatomical Visualization of Myocardial Bridge and Tunneled Artery in Human Heart Specimens**



(A and B) Adult human heart specimens in which the epicardial fat has been carefully removed to allow direct visualization of the coronary arteries, which have been manually painted in red. (A) The left anterior descending artery (LAD) is seen following its epicardial course, with a clearly identifiable segment passing beneath a muscular band, consistent with a myocardial bridge. On the lateral wall, a deeply intramyocardial segment—classified as a tunneled artery—can also be observed. (B) Note a mid-LAD myocardial bridge; in the right-hand image, the overlying myocardial layer has been removed (red arrow), revealing the impression left by the artery embedded within the myocardium.

FIGURE 2 **Multimodal Anatomical and Clinical Imaging of Myocardial Bridging**



(A and B) Human adult heart specimen with coronary arteries manually painted for anatomical delineation. Note the presence of both "bridged" and "fully tunneled" coronary segments across multiple regions of the heart in both anterior or sternocostal (A) and left lateral (B) views. (C) Histological section at the level of the right ventricular outflow tract (RVOT) confirming a deeply intramyocardial course of the left anterior descending artery (LAD) beneath the epicardium, adjacent to the pulmonary valve. (D to F) Images corresponding to the same patient: (D and E) Coronary computed tomography imaging (photon-counting CT) demonstrates a long intramyocardial segment of the mid LAD (red arrows). The tunneled segment measures approximately 40 mm. (F) Coronary angiography demonstrating a classic "milking effect" (red arrow) of the LAD caused by systolic compression of the tunneled artery.

Diagnosis requires a combination of anatomical and functional assessment. Although invasive coronary angiography may show the classic "milking effect," its sensitivity is limited.[1,2] Coronary computed tomography angiography is considered the noninvasive reference standard for anatomical assessment, with high sensitivity and specificity for detecting MB and characterizing its morphology (**Figure 2**).[1-5] Intravascular

TABLE 1 **Comparative Value of Imaging and Functional Techniques in Myocardial Bridge Assessment**

Evaluation Methods	Primary Clinical Utility	Sensitivity*	Specificity*	Key Insights
Coronary angiography	Moderate (functional, not anatomical)	50%-70%	90%	Visualizes "milking effect"; underestimates depth/length; limited for superficial bridges[1,2]
Coronary computed tomography angiography	Very high (anatomy and extent)	90%-95%	95%	Noninvasive gold standard; excellent for length/depth and relation to adjacent structures[1-5]
Intravascular ultrasound	Very high (intramural morphology)	80%-90%	90%	Assesses systolic compression; distinguishes from atherosclerotic plaque[1,4]
Optical coherence tomography	Limited in deep bridges	60%-70%	85%	High resolution for superficial bridges[1]
Fractional flow reserve/diastolic fractional flow reserve	Functional; assesses hemodynamic impact	60%-80%	90%	Useful if ischemia suspected; may require pharmacologic provocation (eg, dobutamine)[1,4,6,7]

This table summarizes the diagnostic value, sensitivity, specificity, and key comments with references for each imaging modality in the evaluation of myocardial bridging. *Sensitivity and specificity values are approximate and may vary depending on population and reference standard.

ultrasound provides detailed intramural morphology and dynamic assessment, whereas optical coherence tomography is mainly useful for superficial bridges owing to its limited tissue penetration.[1,4] Functional tests such as fractional flow reserve or diastolic fractional flow reserve under pharmacologic stress help assess hemodynamic significance and are recommended in patients with ischemic symptoms and MB, especially when noninvasive imaging is inconclusive (**Table 1**).[1,4,6,7]

FUNDING SUPPORT AND AUTHOR DISCLOSURES

The authors have reported that they have no relationships relevant to the contents of this paper to disclose.

ADDRESS FOR CORRESPONDENCE: Dr José-Ángel Cabrera, Cardiology Department, Hospital Universitario QuirónSalud-Madrid, Universidad Europea de Madrid, Calle Diego de Velázquez, 1, Pozuelo de Alarcón, Madrid 28223, Spain. E-mail: jose.cabrera@quironsalud.es.

REFERENCES

1. Sternheim D, Power DA, Samtani R, Kini A, Fuster V, Sharma S. Myocardial bridging: diagnosis, functional assessment, and management: JACC state-of-the-art review. *J Am Coll Cardiol*. 2021;78(22):2196–2212.

2. Leschka S, Koepfli P, Husmann L, et al. Myocardial bridging: depiction rate and morphology at CT coronary angiography—comparison with conventional coronary angiography. *Radiology*. 2008;246(3):754–762. https://doi.org/10.1148/radiol.2463062071

3. Gannon MP, Cerci RJ, Valdiviezo C, et al. Combined computed tomography angiography-computed tomography perfusion in the identification and prognostic assessment of myocardial bridging from the CORE320 study: 5-year follow-up. *Am J Cardiol*. 2023;207:314–321. https://doi.org/10.1016/j.amjcard.2023.08.040

4. Forsdahl SH, Rogers IS, Schnittger I, et al. Myocardial bridges on coronary computed tomography angiography—correlation with intravascular ultrasound and fractional flow reserve. *Circ J*. 2017;81(12):1894–1900. https://doi.org/10.1253/circj.CJ-17-0284

5. Rovera C, Moretti C, Bisanti F, De Zan G, Guglielmo M. Myocardial bridging: review on the role of coronary computed tomography angiography. *J Clin Med*. 2023;12(18):5949. https://doi.org/10.3390/jcm12185949

6. Yu Y, Yu L, Dai X, Zhang J. CT fractional flow reserve for the diagnosis of myocardial bridging-related ischemia: a study using dynamic CT myocardial perfusion imaging as a reference standard. *Korean J Radiol*. 2021;22(12):1964–1973. https://doi.org/10.3348/kjr.2021.0043

7. Danek BA, Kearney K, Steinberg ZL. Clinically significant myocardial bridging. *Heart*. 2023;110(2):81–86. https://doi.org/10.1136/heartjnl-2022-321586

KEY WORDS cardiac anatomy, coronary computed tomography angiography, intravascular imaging, ischemia, myocardial bridging

APPENDIX For a supplemental video, please see the online version of this paper.