Prevalence and Characteristics of Myocardial Bridges in Multidetector Row Computed Tomography Coronary Angiography

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Received:: 26/02/2009
Accepted: 06/18/2009

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SUMMARY

Background
Myocardial bridging (MB) are congenital defects of the coronary arteries in which a segment of an epicardial artery lies in the myocardium for part of its course. The current gold standard for diagnosing MB is coronary angiography; however other invasive techniques are also useful. Myocardial bridging can also be visualized with the use of novel non-invasive imaging techniques such as multidetector-row computed tomography coronary angiography (MDCT-CA).

Objectives
To assess the prevalence and characteristics of myocardial bridging in patients undergoing multidetector-row computed tomography coronary angiography (MDCT-CA).

Material and Methods
A total of 452 consecutive patients were evaluated with 16-row and 64-row MDCT-CA due to the presence of abnormal findings in myocardial perfusion image tests, symptoms suggestive of coronary artery disease, and in asymptomatic patients with a family history of coronary artery disease. The presence of MB, their location and characteristics were analyzed. Myocardial bridges were classified as complete and incomplete with respect to continuity of the myocardium over the tunneled segment of the artery involved. Quantitative measurements of vessel diameter during systole and diastole were evaluated.

Results
The prevalence of MB was 35.18%; 88 were complete and 71 incomplete. Among complete MB, 6 affected both systole and diastole, 27 presented only systolic compression and 55 showed no compression. Incomplete MB showed absence of arterial compression.

Conclusions
Multidetector-row computed tomography coronary angiography detected a higher prevalence of MB in the study population and allowed to classify them and to assess their functional aspects throughout the cardiac cycle.

REV ARGENT CARDIOL 2009;77:268-273.

Key words > Myocardial Bridging - Congenital Abnormalities - Coronary Vessels - Tomography - Coronary Angiography

Abbreviations >

MDCT-CA	Multidetector row computed tomography coronary angiography	**MB**	Myocardial bridges
LAD	Left anterior descending		

BACKGROUND

Myocardial bridges (MB) are congenital defects of the coronary arteries in which a segment of an epicardial artery lies in the myocardium for part of its course. (1, 2) They were initially identified in necropsies by Reyman in 1793 (3) and were then described by Portmann and Iwig (4) in 1960 in angiographies. Myocardial bridges are most commonly localized in the left anterior descending (LAD) coronary artery and are mostly asymptomatic. Yet, angina, arrhythmias, myocardial ischemia, atrioventricular block, left ventricular dysfunction, myocardial stunning, myocardial infarction and sudden cardiac death have been asso-

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ciated with myocardial bridging. (1) The current gold standard for diagnosing myocardial bridges is conventional coronary angiography; however other invasive techniques, such as intravascular ultrasound and intracoronary Doppler ultrasound, are also useful (1, 5-7). Myocardial bridging can also be visualized with the use of novel noninvasive imaging techniques such as multidetector row computed tomography coronary angiography (MDCT-CA).This technique, which provides adequate diagnosis of coronary artery disease and severity of stenosisis, is also useful for the detection and clasification of coronary artery anomalies. (6, 8, 9)

The goal of the present study is to determine the prevalence and characteristics of MB in a population of patients undergoing MDCT-CA.

MATERIAL AND METHODS

The study protocol was approved by the Committee on Ethics of our institution. We included 452 patients (376 were men; mean age 63 ± 10.4 years; range: 28-84 years) with abnormal findings in myocardial perfusion image tests, symptoms suggestive of myocardial ischemia, or asymptomatic patients with a family history of coronary artery disease. Exclusion criteria included irregular rhythm, serum creatinine level > 1.5 mg/ml, history of allergy to iodinated contrast agents and clinical instability. Given the fact that elevated heart rate compromises image quality, patients whose heart rate was > 60 beats per minute received 50-100 mg of oral metoprolol (Belozok; AstraZeneca S.A., Buenos Aires, Argentina) 24 hours before the study and one hour before image acquisition if needed, and/or intravenous propranolol (Oposim Richet; Laboratorios Richet S.A., Buenos Aires, Argentina) at a dose of 2 mg until a maximum total of 10 mg.

All MDCT-CA examinations were performed with retrospective gated technique using 16 and 64-detector scanners (Brilliance CT64; Philips Medical Systems, Highland Heights, OH) in 300 and 152 patients, respectively. After placing an antecubital 18-gauge IV access, 80 - 100 ml of iodinated contrast agent were administered at a flow rate of 4-6 ml/s and the entire heart was scanned within a single breath-hold. In patients studied with a 64-detector scanner a saline flush of 40 ml was administered after contrast agent injection. Also, 2.5 mg of sublingual isosorbide dinitrate were administered immediately before cardiac scan. Images were reconstructed at different phases of the cardiac cycle (0%, 12.5%, 25%, 37.5%, 50%, 62.5%, 75%, 87.5% and 95%).

The phase at 75% of the cardiac cycle was systematically evaluated in all patients. The remaining phases were evaluated in case of findings suggestive of MB (an artery tunneled through a part of the heart muscle or a change in the epicardial artery course towards the myocardium). Axial images, multiplanar reconstructions, three-dimensional and maximum intensity projection images were analyzed. Myocardial bridges were classified as complete and incomplete. In complete myocardial bridging, a segment of the artery is completely covered by the myocardium, while incomplete bridges are not fully covered by myocardial fibers, but by a thin layer of connective tissue and fatty tissue. Reformatted images in the sagittal plane were used to visualize the functional characteristics of MB during the cardiac cycle. Systolic compression of the tunneled segment was defined as reduction in luminal diameter >50% compared to the proximal segment of the same artery with normal epicardial course. We determined the prevalence and location MB in the study population.

RESULTS

Image quality was appropriate in all scan examinations and no procedure-related complications were reported. Mean radiation dose was 10.3 mSv when 16-detector scanners were used and 15.2 mSv for 64-detector scanners.

A total of 159 MB were detected with MDCT-CA; 88 complete MB were identified in 149/452 patients. Ten patients presented MB in two different coronary arteries (Figures 1 and 2). The prevalence of MB in the study population was 35.18%. The characteristics of MB in our population are shown in Table 1; Table 2 describes their functional aspects throughout the cardiac cycle.

None of the patients with MB and absence of compression of the tunneled segment during the cardiac cycle were symptomatic, while the 6 patients with compression presented symptoms. Compression was

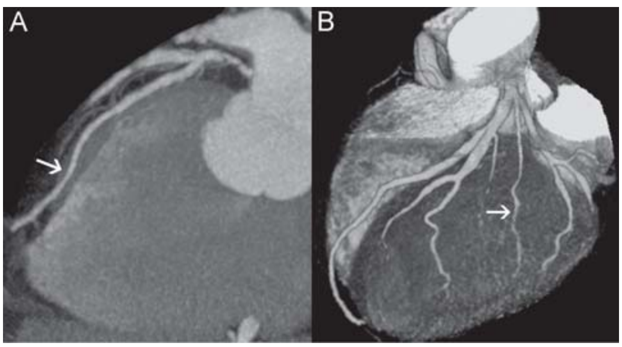

Fig. 1. A 64-detector MDCT-CA from a 53-year-old woman with complete myocardial bridging of the ramus intermedius (*arrow*). **A.** Sagittal maximum intensity projection reconstruction image. **B.** Three-dimensional reconstruction.

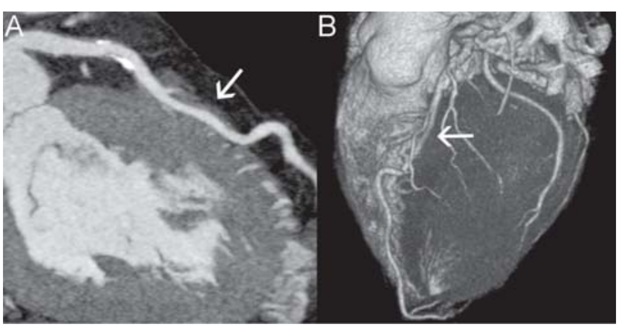

Fig. 2. A 64-detector MDCT-CA from a 55-year-old man with complete myocardial bridging of the left aner descending coronary artery (*arrow*). **A.** Sagittal maximum intensity projection reconstruction image. **B.** Three-dimensional reconstruction.

not detected in any patients with incomplete MB during the phases of the cardiac cycle (Figures 3 and 4). In complete MB with absence of significant compression during the cardiac cycle, the average difference between the diameters of the tunneled segment versus the proximal segment was 0.23 mm ± 0.10 mm during the systolic phase, representing an 8.10% ± 3.71% on lumen reduction, and 0.48 mm ± 0.18 mm during the diastolic phase, representing a 14.85% ± 4.33% on lumen reduction. In cases of systolic compression, the average difference between the diameters of the intramyocardial segment versus the proximal reference was 1.63 mm ± 0.5 mm during the systolic phase, representing a 54.66% ± 4.28% on lumen reduction, and 0.38 mm ± 0.15 mm during the diastolic phase, representing a 12.75% ± 4.30% on lumen reduction. In this group of patients, only three presented symptoms (two patients with-atypical chest pain and one with angina); coronary angiography confirmed the presence of MB and ruled out coronary artery disease. Finally, in presence of systolic and diastolic compression, the average difference between the diameters of the intramyocardial segment versus the proximal reference was 1.6 mm ± 0.5 mm during the systolic phase, representing a 54.58% ± 4.06% on lumen reduction, and 1.75 mm ± 0.51 mm during the diastolic phase, representing a 56.28% ± 3.87% on lumen reduction. Three of these patients had chest pain; in one patient chest pain propagated to the left shoulder during exercise and two patients complained of chest oppression. In all cases, SPECT scans revealed perfusion defects. Coronary angiography confirmed the presence of MB of the mid LAD in the three cases and absence of significant coronary artery disease (Figure 5).

Table 1. Characteristics of myocardial bridges found in MDCT-CA scans

Total mb	159
Complete MB	88 (55.4%)
Incomplete MB	71 (44.6%)
Localization	
Mid-LAD artery segment	94 (59.1%)
Distal LAD artery segment	10 (6.3%)
Diagonal branch	18 (11.3%)
Circumflex coronary artery	21 (13.2%)
Rmus intermedius	16 (10.1%)

MDCT-CA: Multidetector row computed tomography coronary angiography. MB: Myocardial bridges

Table 2. Functional aspects of myocardial bridges in the different phases of cardiac cycle

	Absence of compression	Systolic compression	Systolic-diastolic compression
Incomplete MB	71	0	0
Complete MB	55	27	6

MB: Myocardial bridges

DISCUSSION

The coronary arteries normally course over the epicardial surface of the heart. Myocardial bridges are congenital defects of the coronary arteries in which a segment of an epicardial artery is covered by muscle fibers, and systolic compression of the compromised vessel is the main angiographic finding. These defects are generally asymptomatic. (2, 6) However, MB should be recognized and treated due to their association with myocardial ischemia. (10.13) Coronary angiography is the current gold standard for diagnosing MB; yet, this is an invasive procedure. The advent of novel image diagnostic techniques, such as MDCT-CA, intravascular ultrasound, intracoronary Doppler ultrasound and intracoronary pressure measurement are useful to visualize and quantify morphological and functional changes of MB. (2) Recent studies have demonstrated that coronary artery compression may not be limited to the systole but may persist during the diastole, compromising the diastolic coronary flow. (7) Nowadays, MDCT-CA provides adequate evaluation of the coronary arteries not only in cases of stenosis but also in presence of coronary artery anomalies. (9)

The prevalence of MB diagnosed by coronary angiography is low, < 5%, probably due to the presence of thin MB causing little compression, or to superficial and incomplete MB which may be underdiagnosed by conventional coronary angiography. (2, 6, 14) In our series, the prevalence of MB was 35.18%, a number

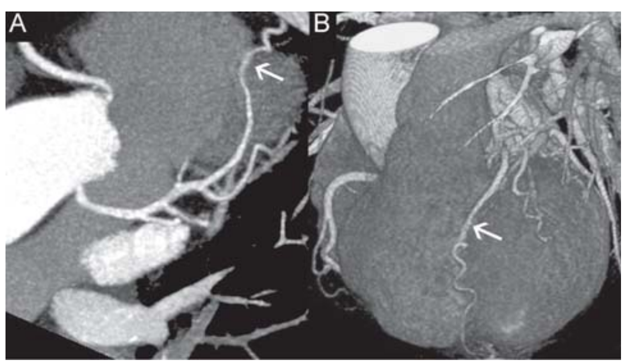

Fig. 3. A 64-detector MDCT-CA from a 64-year-old man with incomplete myocardial bridging of distal left anterior descending coronary artery (*arrow*). **A.** Sagittal multiplanar reconstruction. **B.** Three-dimensional reconstruction.

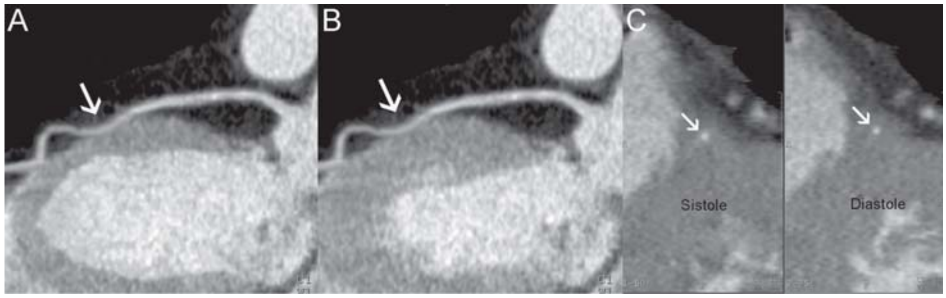

Fig. 4. A 16-detector MDCT-CA from a 56-year-old man with incomplete myocardial bridging of mid left anterior descending (LAD) coronary artery (*arrow*). **A.** Sagittal multiplanar reconstruction in systole, showing the intramyocardial course of the mid-LAD and absence of compression of the tunneled segment. **B.** Sagittal multiplanar reconstruction in systole, showing the intramyocardial course of the mid-LAD and absence of compression of the tunneled segment. **C.** Orthogonal section of the tunneled segment (*arrow*) in systole and diastole.

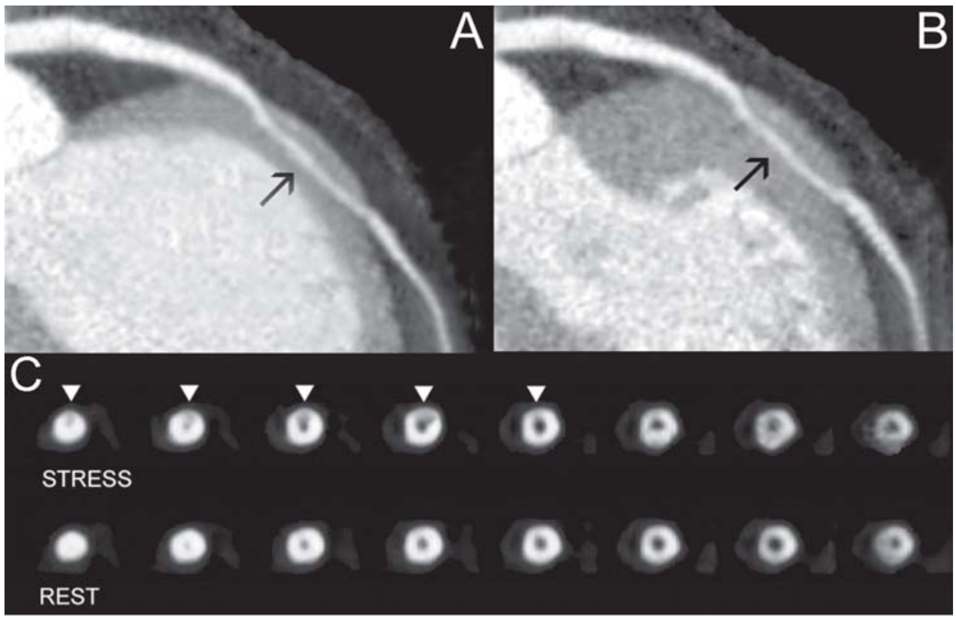

Fig. 5. 16-detector MCT-CA and perfusion image in rest and stress in a 36-year-old man with complete myocardial bridging of the mid left anterior desceng (LAD) coronary artery (*arrow*). **A.** Sagittal multiplanar reconstruction in diastole, showing the intramyocardial course of the mid-LAD and compression of the tunneled segment. **B.** Sagittal multiplanar reconstruction in systole, showing the intramyocardial course of the mid-LAD and the compression of the tunneled segment. **C.** Myocardial perfusion scintigraphy demonstrating ischemia in the territory of the LAD.

significantly higher than the one reported in angiographic series, but similar to the prevalence communicated in autopsy studies. (2, 15)

We also found that MB affected mostly the midportion of the LAD coronary artery, a finding similar to the one previously reported. (2, 15) Other coronary arteries may also be compromised. (16, 17) Yet, we did not find MB of the right coronary artery.

Myocardial bridges are classified as "complete" and "incomplete". In complete myocardial bridging, the tunneled artery is completely surrounded by a band of myocardial muscle, while incomplete bridges are not fully covered by myocardial fibers, but by a thin layer of connective tissue. (6) In addition, complete MB may be classified according to their functional aspects during the cardiac cycle. In patients in whom compression is limited to the systole, the presence of symptoms is related to the degree of compression; yet, myocardial perfusion image studies are generally negative for ischemia. On the contrary, the presence of symptoms and signs of myocardial ischemia in myocardial perfusion scans is frequent in patients who have a high degree of systolic and diastolic compression. We found that all our patients with MB and absence of compression of the tunneled segment, and most of those with a certain degree of compression during the cardiac cycle, were free from symptoms Symptoms were present in only 6 patients with MB and systolic or systolic-diastolic compression. Different mechanisms have been proposed to explain ischemia in MB. (2, 6, 18) Neither nonsignificant stenosis proximal to the bridge nor systolic compression of the tunneled segment alone can sufficiently explain severe ischemia and associated symptoms in these patients. (2) Two different mechanisms have been proposed to explain the physiopathology of BM: a) systolic compression with reduction in lumen diameter that persists in mid to late diastole; and, b) increase in intracoronary Doppler flow velocities with qualitative abnormal flow patterns. (19) Multidetector row CT-CA may clearly detect and evaluate the diameter reduction of the intramyocardial segment using reformations in the sagittal plane and three-dimensional images during the different phases of the cardiac cycle; therefore, it is a useful tool for the management of these patients.

Symptomatic patients are managed with medical treatment and surgery ins exceptionally required. All our patients had favorable outcomes with medical treatment. In subjects refractory to medication, percutaneous coronary angioplasty and stent implant is a useful choice, while surgical myotomy should be limited to patients with severe angina and evidence of clinically relevant ischemia. (2, 20, 21)

One of the limitations of this technique is the high radiation dose delivered in order to obtain appropriate image quality of the functional aspects of MB during the different phases of the cardiac cycle. The use of novel techniques, such as tube current modulation or electrocardiogram-prospectively gated MDCT-CA, have proved to reduce effective dose radiation by 50% and 80%, respectively and allow images construction of the coronary tree at 75% of the R-R interval (midiastolic phase). This methodology enables adequate characterization of complete and incomplete MB and is useful to evaluate the presence of diastolic compression.

In addition, MDCT-CA provides the opportunity to recognize the presence, depth and length of the tunneled segment of the artery before bypass graft surgery and gives the surgical team the opportunity to plan the best surgical approach in order to save as much time as possible and avoid potential complications.

CONCLUSIONS

Multidetector-row computed tomography coronary angiography detected a higher prevalence of MB than expected and made it possible to classify them and to assess their functional aspects throughout the cardiac cycle. The presence of intramyocardial coronary segments should be ruled out in patients with low risk for coronary artery disease who present atypical chest pain or abnormal findings in myocardial perfusion image tests.

RESUMEN

Prevalence and Characteristics of Myocardial Bridging in Multidetector-Row Computed Tomography Coronary Angiography

Introducción
Los puentes miocárdicos (PM) representan una anomalía congénita de las arterias coronarias en la que un segmento de una arteria coronaria principal, de habitual trayecto epicárdico, transcurre dentro del miocardio describiendo un curso intramural. Aunque el método diagnóstico de referencia es la angiografía convencional, existen otras técnicas invasivas. Con el advenimiento de la angiografía coronaria por tomografía computarizada multidetector (ACTCM) ha surgido una alternativa no invasiva para su evaluación.

Objetivos
Evaluar la prevalencia y las características de los puentes miocárdicos en pacientes examinados con angiografía coronaria por tomografía computarizada multidetector (ACTCM).

Material y métodos
Se evaluaron en forma consecutiva 452 pacientes con ACTCM de 16 y 64 filas. Los motivos de la solicitud médica incluyeron hallazgos patológicos en estudios de perfusión miocárdica, síntomas sugestivos de enfermedad coronaria y pacientes asintomáticos con antecedentes heredofamiliares de enfermedad coronaria. Se determinaron la presencia, la localización y las características de los PM, los cuales se clasificaron en completos e incompletos según el grado de tunelización de la arteria involucrada. Se evaluó también su comportamiento durante la sístole y la diástole.

Resultados
La prevalencia de PM fue del 35,18%; se identificaron 88 casos de PM completos y 71 incompletos. Dentro del grupo de los PM completos, 6 mostraron compresión sistólica-diastólica, 27 sólo compresión sistólica y 55 no mostraron compresión. En el grupo de los PM incompletos no se detectaron casos con compresión arterial.

Conclusiones
La ACTCM mostró una prevalencia de PM mayor que la esperada en la población en estudio y permitió su clasificación y la evaluación de su comportamiento durante las fases del ciclo cardíaco.

Palabras clave > Puente miocárdico - Anomalías congénitas - Vasos coronarios - Tomografía - Angiografía coronaria por tomografía

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Competing interests

None declared.

Acknowledgments

The authors are grateful to Dr. Graciela Fernández Alonso for her assistance in the manuscript preparation.