Prevalence and Imaging Findings of Myocardial Bridging on Multi-Slice CT Coronary Angiography

Miyokardiyal Köprülerin Çok Kesitli BT Anjiyografide Sıklığı ve Görüntüleme Bulguları

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ABSTRACT Objective: We aimed to evaluate the prevalence, appearance, and accompanying atherosclerotic findings of myocardial bridging (MB) by using 16-detector multi-slice computed tomography (MSCT). **Material and Methods:** Between January 2005 and February 2008, 1380 consecutive coronary computed tomography angiography (CTA) which were performed due to suspicion of coronary artery disease, were evaluated. **Results:** Ninety of them were excluded from analysis due to poor image quality. A total of 122 MBs were detected in 94 of 1290 coronary CTA (7.3%). The distribution of MBs in accordance with the coronary arteries are as follows: 6.6% at proximal left anterior descending coronary artery (LAD), 47.5% at middle LAD, 9.8% at distal LAD, 16.4% at diagonal arteries, 8.2% at intermediate artery, and 11.5% at obtuse marginal artery. The lengths of intra-myocardial segment (tunnelled artery) were between 5 and 40 mm, and the depths within myocardium were between 0.5 and 7 mm. In addition, atherosclerotic findings varying from plaque to severe stenosis were present in the 45% of arteries with MB. **Conclusion:** The prevalence of MB in coronary CTA was comparatively lower than in autopsy studies, but higher than in catheter angiography studies. CTA provides non-invasive determination of both superficial and deep MB. It is useful to show the length and depth of tunnelled artery and accompanying atherosclerotic findings for determining the cause of patient symptoms.

Key Words: Myocardial bridging; coronary vessels; tomography, spiral computed

ÖZET Amaç: On altı dedektörlü çok kesitli bilgisayarlı tomografi (ÇKBT)'de miyokardiyal köprüler (MK)'in sıklığını, görünüm özelliklerini ve eşlik eden aterosklerotik bulguları değerlendirmektir. **Gereç ve Yöntemler:** Ocak 2005 ile Şubat 2008 tarihleri arasında koroner arter hastalığı şüphesiyle uygulanan ardışık 1380 koroner BT anjiyografi tetkiki MK varlığı açısından değerlendirildi. **Bulgular:** Doksan BT anjiyografi tetkiki görüntü kalitesinin yeterli olmaması nedeni ile değerlendirme dışı bırakıldı. Geride kalan 1290 BT anjiyografide 94 (%7.3) hastada 122 MK saptandı. MK'lerin koroner arterlere dağılımı şöyleydi. Proksimal sol ön inen koroner arter (LAD): %6.6, orta kesim LAD: %47.5, distal LAD: %9.8, diagonal arterler: %16.4, intermediat arter: %8.2 ve obtüz marjinal arter: %11.5. MK'de intramiyokardiyal segmentlerin uzunluğu 5-40 mm ve miyokard içindeki derinlikleri ise 0.5-7 mm arasında değişmekteydi. Ayrıca MK olan koroner arterlerde %45 oranında plaktan ciddi daralmaya kadar değişen ek aterosklerotik bulgular mevcuttu. **Sonuç:** Koroner BT anjiyografide MK sıklığını otopsi çalışmalarında belirtilenden daha az, kateter anjiyografi çalışmalarında belirtilenden ise daha yüksek bulduk. Koroner BT anjiyografi hem yüzeyel hem de derin seyirli MK'yi non-invaziv olarak tespit edebilir. Hastanın şikayetlerinin nedenini belirlemede intramiyokardiyal koroner arter segmentin uzunluğu ve miyokarddaki derinliği ile eşlik eden aterosklerotik bulguları göstermek oldukça yararlıdır.

Anahtar Kelimeler: Miyokard köprüleşmesi; koroner arter; bilgisayarlı tomografi

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Myocardial bridging (MB) is defined as an intramural segment of a coronary artery that normally courses epicardially. The intramyocardial coronary segment is called tunnelled artery. MB is mostly located in the mid-portion of the LAD coronary artery.[1-6] Although MB is an asymptomatic condition in generally, it can cause ischemic symptoms especially during certain efforts.[7-9] Moreover, this anomaly has been associated with various clinical manifestations such as unstable angina, myocardial infarction, arrhythmia, and sudden death.[7,10-14] In general, narrowing at systole and widening at diastole in the coronary artery segment during the catheter coronary angiography (it is called milking effect) has been accepted as diagnostic for MB.[1,4,7,13] MB frequency has been reported to be 0.8-4.9% in catheter angiography studies.[7,8,15] However, autopsy studies showed wide variance, ranging from 5% to 86%.[7,8,16]

There are mainly two types of approaches for treatment in patients with symptomatic MB. These are medical (i.e, nitrates, beta-blockers, calcium channel blockers) or interventional (i.e, stent, angioplasty, myotomy, bypass).[7,17,18]

In recent coronary CTA studies by MSCT, MB prevalence was reported to be between 3.5% to 30.5%.[3,19,20] CTA provides not only determination of both superficial and deep MB but also evaluation of adjacent anatomic structures and associated atherosclerotic findings.[4,19-27] Physical activity may lead to myocardial ischemia in patients with deep MB.[7,8,10,12,14] We aimed to evaluate the prevalence, appearance, and accompanying atherosclerotic findings of MB by using ECG gated 16-detector MSCT coronary angiography.

MATERIAL AND METHODS

Between January 2005 and February 2008, 1380 consecutive CTA studies which performed due to suspicion of coronary artery disease (chest pain, positive non-invasive stress test, multiple atherosclerotic risk factors etc.) were evaluated by a radiologist experienced in coronary CTA.

At our department, CTA examinations were routinely performed with 16 -detector row computed tomography scanner (Aquilion 16 system, Toshiba Medical Systems Corporation, Japan). For patients with heart rate over 75 per minute, 50-100 mg beta-blocker (metoprolol) orally one hour prior to examination or 5-10 mg metoprolol intravenously just before examination was administered. Technical factors were as follows; kVP: 120-135, mA: 350, detector collimation: 16 x 1 mm, pitch: 0.25, rotation time: 0.5 sec, slice thickness: 1 mm, reconstruction interval: 0.5 mm. Contrast material was used as follows: 80-100 mL non-ionic iodine contrast material (Ultravist 370, Schering or Iomeron 400, Bracco) with a speed of 4-5 mL/sec using an automatic injector.

The axial images were obtained at diastolic phase (between 40% and 80% of R-R interval) using retrospective ECG gating procedure. The images were evaluated at the Vitrea Work Station (Vital images, Minnesota, USA). In case of coronary artery segment under the myocardial fibers was accepted as a MB, especially on multi-planar reformat (MPR) images (Figure 1-4). Localization of MB and associated atherosclerotic findings were reported. Length and depth of tunnelled artery was measured on axial and oblique reformatted images. MBs were separated into two groups as "superficial" or "deep" in according to muscle thickness over the tunnelled artery. If the muscle thickness was less than 1 mm, it was accepted as "superficial" or 1 mm and more it was accepted as "deep".

RESULTS

Among 1380 coronary CTA examinations, 90 of them were excluded from analysis due to poor image quality secondary to motion artifact. A total of 122 MBs were detected in 94 of 1290 coronary CTA examinations (7.3%). The mean age of patients with MB including 74 males and 20 females was 54 (range 30-80) years.

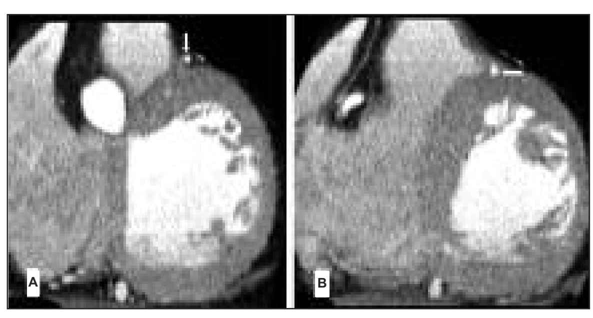

FIGURE 1: Curved MPR images show normal epicardial (A) and intra-myocardial coronary artery (B) on CTA.

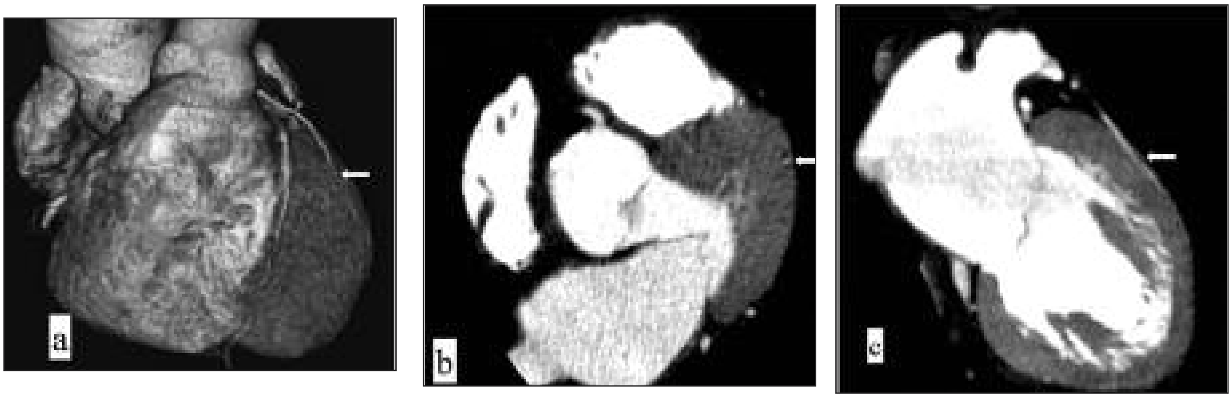

FIGURE 2: Superficial myocardial bridging at diagonal artery: 3D volume rendered (A), axial (B), curved MPR image (C) on CTA.

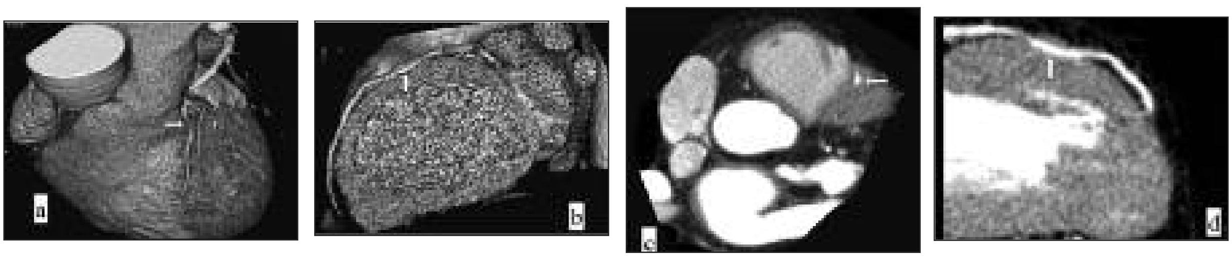

FIGURE 3: Deep myocardial bridging at mid portion of LAD: 3D volume rendered (A), oblique 3D volume rendered (B), axial (C) and curved MPR image (D) on CTA.

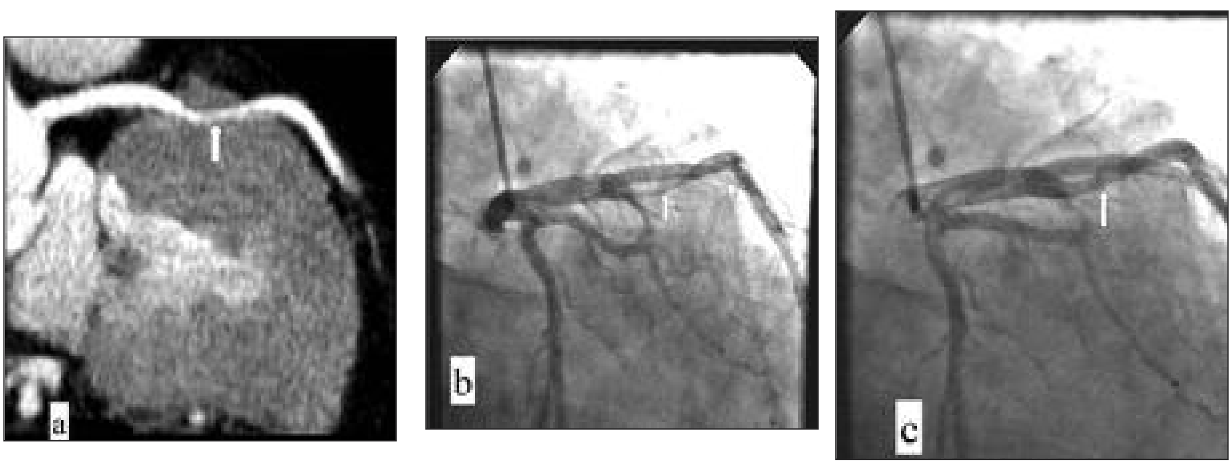

FIGURE 4: Deep myocardial bridging: Notice the narrowing during intra-myocardial course at the curved MPR image (A) on CTA. Catheter angiography images show narrowing at systole (B) and widening at diastole (C) at mid portion of LAD (milking effect). Diastolic widening is not completely.

MB was present a single localization in 68 patients, two different localization in 24 patients, and three different localization in 2 patients. The distribution of MBs in accordance with coronary arteries is shown in Table 1. The depths of MB were between 0.5-7 mm (mean= 1.7 mm), and the lengths were between 5-40 mm (mean= 18 mm). 33% of MBs (n= 40) were superficial and 67% of them were deep (n= 82). Accompanying atherosclerotic findings (varying from plaque to severe stenosis) were present in the 45% of coronary arteries with MB. The distribution of these findings according to CTA were as the following: slight (%0-49 narrowing): 21%, moderate (%50-69 narrowing): 10%, severe (%70 and more narrowing): 14%. Atherosclerotic findings were present proximal to MB in 70% and distal to it in 30%.

TABLE 1: Distribution of MBs in coronary arteries.

Coronary Artery	Number of MBs	%
LAD proximal	8	6.6
LAD middle	58	47.5
LAD distal	12	9.8
Diagonals	20	16.4
Intermediate	10	8.2
Obtuse marginal	14	11.5
Right	0	0
Total	**122**	**100**

DISCUSSION

In the past, diagnosis of MB was provided by viewing of the "milking effect" in catheter angiography. In catheter angiography studies, the prevalence of MB has been reported to be 0.8-4.9%.[7,8,15] In CTA studies, however, MB prevalence was shown much higher (3.5-30.5%) than catheter angiography.[3,19,20] The sensitivity of CTA in detecting of MB is much higher due to good delineation of coronary artery and its relation to adjacent myocardium. The most frequent localization of MB is in the LAD both catheter coronary angiography and CTA studies. In our study, MBs were located 80.3% in the LAD.

It is mandatory to show a coronary artery segment penetrates through the myocardium for the diagnosis of MB. Therefore, it is helpful the evaluating of axial, MPR, and 3D images on CTA (Figure 1-4). Additional clues are angulation of the tunnelled artery while leaving the myocardium and the narrower diameter of the intra-myocardial segment than the adjacent epicardial segment (Figure 3, 4). The MPR images are essential to measure the length, depth, and diameter of tunnelled artery.

In our study, all MBs were at the left side. We did not detect a MB at the right coronary artery. The percentages of MB are as follows: 6.6% at proximal LAD, 47.5% at middle LAD, 9.8% at distal LAD, 16.4% at diagonal arteries, 8.2% at intermediate artery, and 11.5% at obtuse marginal artery. The prevalence of MB was reported to be 26% in 300 patients with atypical chest pain in Zeina et al CTA study (using 16- and 64-detector MSCT).[19] In their study, the percentages for localization of MBs were as follows: 61.5% at mid LAD, 23% at distal LAD, 1.3% at first diagonal artery, 1.3% at second diagonal artery, 2.6% at ramus artery, 1.3% at right coronary artery, and 2.6% at obtuse marginal artery. Konen et al reported 30.5% MB prevalence in their study (using 40- and 64-detector MSCT) in 118 patients with suspected coronary artery disease or known coronary artery disease.[3] MB localizations were reported in Konen et al study as follows: 57.4% at mid LAD, 15% at distal LAD, 12.8% at diagonal branches, 8.5% at intermediate artery, and 6.3% at obtuse marginal artery. Kantarci et al reported 3.5% prevalence for MB in 626 patients using 16-detector MSCT.[20] In addition, all MBs were at the LAD in their study. Our study consisted of larger patient groups (n= 1290) and we found 7.3% prevalence for MB. This prevalence is lower than the study of Zeina et al and Konen et al, but higher than Kantarci et al. The higher prevalence rate of MB may be related to high temporal resolution and image quality which is due to the use of 40 and 64 detector MSCT.

Ferreira et al divided intra-myocardial LAD into two types in a necropsy study of 90 consecutive hearts: the superficial type (76%) in which coronary segment runs on the inter-ventricular groove, and the deep type (24%) in which intra-myocardial segment deviates toward right ventricle and is crossed by a muscle bundle arising from right ventricle.[28] Konen et al divided MB for the LAD into three types according to their depth and course: superficial, deep, and right ventricular types.[3] They determined muscle thickness of 1mm as a borderline in order to discriminate superficial and deep type MB. Considering the thickness of muscle on the coronary artery segment, we separated all MBs into two groups as the "superficial" and "deep" using 1mm borderline. In conclusion, 33% of MBs were superficial and 67% of them were deep.

Our results also showed that atherosclerotic findings varying from plaque to stenosis (slight, moderate, severe) were present in the 45% of coronary arteries with MB. These findings were proximal to MB in 70% and distal to it in 30%. This result shows that there may be a tendency to atherosclerosis in arteries with MB. Zeina et al[19] reported similar results in this subject.

CONCLUSION

We found that the prevalence of MB in the coronary CTA was comparatively lower than in autopsy studies, but it was higher than in catheter angiography studies.

Coronary CTA can easily determine superficial or deep intra-myocardial coronary segment. It is useful to show the length and depth of tunnelled artery and accompanying atherosclerotic findings for determining the cause of patient symptoms.

REFERENCES

1. Noble J, Bourassa MG, Petitclerc R, Dyrda I. Myocardial bridging and milking effect of the left anterior descending coronary artery: normal variant or obstruction? Am J Cardiol 1976;37(7):993-9.
2. Kramer JR, Kitazume H, Proudfit WL, Sones FM Jr. Clinical significance of isolated coronary bridges: benign and frequent condition involving the left anterior descending artery. Am Heart J 1982;103(2):283-8.
3. Konen E, Goitein O, Sternik L, Eshet Y, Shemesh J, Di Segni E. The prevalence and anatomical patterns of intramuscular coronary arteries: a coronary computed tomography angiographic study. J Am Coll Cardiol 2007; 49(5):587-93.
4. Goitein O, Lacomis JM. Myocardial bridging: noninvasive diagnosis with multidetector CT. J Comput Assist Tomogr 2005;29(2):238-40.
5. Choi HS, Choi BW, Choe KO, Choi D, Yoo KJ, Kim MI, et al. Pitfalls, artifacts, and remedies in multi- detector row CT coronary angiography. Radiographics 2004;24(3):787-800.
6. Özbağ D, Hatipoğlu ES. [The investigation of relationship between the thickness of myocardial bridge and coronary artery in human, dog, sheep and goat]. Turkiye Klinikleri J Med Sci 2002;22(4):385-9.
7. Möhlenkamp S, Hort W, Ge J, Erbel R. Update on myocardial bridging. Circulation 2002; 106(20):2616-22.
8. Alegria JR, Herrmann J, Holmes DR Jr, Lerman A, Rihal CS. Myocardial bridging. Eur Heart J 2005;26(12):1159-68.
9. Çelik T, İyisoy A, Kurşaklıoğlu H, Köse S, Amasyalı B, Işık E. [An interesting type of myocardial bridge causing myocardial ischemia: septal myocardial bridge: case report]. Turkiye Klinikleri J Cardiovasc Sci 2006;18(1):84-6.
10. Roul G, Sens P, Germain P, Bareiss P. Myocardial bridging as a cause of acute transient left heart dysfunction. Chest 1999;116(2):574-80.
11. Tauth J, Sullebarger T. Myocardial infarction associated with myocardial bridging: case history and review of the literature. Cathet Cardiovasc Diagn 1997;40(4):364-7.
12. Yetman AT, McCrindle BW, MacDonald C, Freedom RM, Gow R. Myocardial bridging in children with hypertrophic cardiomyopathy--a risk factor for sudden death. N Engl J Med 1998;339(17):1201-9.
13. Ge J, Jeremias A, Rupp A, Abels M, Baumgart D, Liu F, et al. New signs characteristic of myocardial bridging demonstrated by intracoronary ultrasound and Doppler. Eur Heart J 1999;20(23):1707-16.
14. Yano K, Yoshino H, Taniuchi M, Kachi E, Shimizu H, Watanuki A, et al. Myocardial bridging of the left anterior descending coronary artery in acute inferior wall myocardial infarction. Clin Cardiol 2001;24(3):202-8.
15. Tovar EA, Borsari A, Landa DW, Weinstein PB, Gazzaniga AB. Ventriculotomy repair during revascularization of intracavitary anterior descending coronary arteries. Ann Thorac Surg 1997;64(4):1194-6.
16. Bourassa MG, Butnaru A, Lespérance J, Tardif JC. Symptomatic myocardial bridges: overview of ischemic mechanisms and current diagnostic and treatment strategies. J Am Coll Cardiol 2003;41(3):351-9.
17. Nair CK, Dang B, Heintz MH, Sketch MH. Myocardial bridges: effect of propranolol on systolic compression. Can J Cardiol 1986;2(4): 218-21.
18. Schwarz ER, Klues HG, vom Dahl J, Klein I, Krebs W, Hanrath P. Functional, angiographic and intracoronary Doppler flow characteristics in symptomatic patients with myocardial bridging: effect of short-term intravenous betablocker medication. J Am Coll Cardiol 1996; 27(7):1637-45.
19. Zeina AR, Odeh M, Blinder J, Rosenschein U, Barmeir E. Myocardial bridge: evaluation on MDCT. AJR Am J Roentgenol 2007;188(4): 1069-73.
20. Kantarci M, Duran C, Durur I, Alper F, Onbas O, Gulbaran M, et al. Detection of myocardial bridging with ECG-gated MDCT and multiplanar reconstruction. AJR Am J Roentgenol 2006;186(6 Suppl 2):S391-4.
21. Nieman K, Oudkerk M, Rensing BJ, van Ooijen P, Munne A, van Geuns RJ, et al. Coronary angiography with multi-slice computed tomography. Lancet 2001;357(9256):599-603.
22. Knez A, Becker C, Ohnesorge B, Haberl R, Reiser M, Steinbeck G. Noninvasive detection of coronary artery stenosis by multislice helical computed tomography. Circulation 2000;101(23):E221-2.
23. Schoenhagen P, Halliburton SS, Stillman AE, Kuzmiak SA, Nissen SE, Tuzcu EM, et al. Noninvasive imaging of coronary arteries: current and future role of multi-detector row CT. Radiology 2004;232(1):7-17.
24. Amoroso G, Battolla L, Gemignani C, Panconi M, Petronio AS, Rondine P, et al. Myocardial bridging on left anterior descending coronary artery evaluated by multidetector computed tomography. Int J Cardiol 2004; 95(2-3):335-7.
25. Rychter K, Salanitri J, Edelman RR. Multifocal coronary artery myocardial bridging involving the right coronary and left anterior descending arteries detected by ECG-gated 64 slice multidetector CT coronary angiography. Int J Cardiovasc Imaging 2006;22(5):713-7.
26. Kuettner A, Burgstahler C, Beck T, Drosch T, Kopp AF, Heuschmid M, et al. Coronary vessel visualization using true 16-row multi-slice computed tomography technology. Int J Cardiovasc Imaging 2005;21(2-3):331-7.
27. Hazirolan T, Canyigit M, Karcaaltincaba M, Dagoglu MG, Akata D, Aytemir K, et al. Myocardial bridging on MDCT. AJR Am J Roentgenol 2007;188(4):1074-80.
28. Ferreira AG Jr, Trotter SE, König B Jr, Décourt LV, Fox K, Olsen EG. Myocardial bridges: morphological and functional aspects. Br Heart J 1991;66(5):364-7.