Available online at www.sciencedirect.com

ScienceDirect

Journal of the Chinese Medical Association 74 (2011) 164−168

www.jcma-online.com

Original Article

Myocardial bridging in Taiwanese: Noninvasive assessment by 64-detector row coronary computed tomographic angiography

Ming-Huei Sheu [a,b,*], Yu-Dong Chen [a], Yen-Shu Kuo [c], Mei-Han Wu [a,b], Chun-Ku Chen [a], Cheng-Yen Chang [a,b]

[a] Department of Radiology, Taipei Veterans General Hospital, Taipei, Taiwan, ROC
[b] National Yang-Ming University School of Medicine, Taipei, Taiwan, ROC
[c] Sincere Medical Imaging Center, Central Clinic & Hospital, Taipei, Taiwan, ROC

Received May 20, 2010; accepted November 10, 2010

Abstract

Background: Myocardial bridging (MB) is a congenital structural variant in which a segment of the epicardial coronary artery tunnels into and is surrounded by the myocardium. MB has been correlated to some clinical complications of cardiovascular disease (CVD). The depiction rate of MB varies significantly between catheter coronary angiography and autopsy studies. This study aimed to assess the depiction rate of MB among Taiwanese by coronary computed tomographyic angiography (CCTA), to determine the anatomical features of the tunneling vessels, and to evaluate the outcome of patients having MB.
Methods: Between September 2006 and December 2007, 425 subjects (264 men and 161 women; mean age 59.6 ± 11.7 years) underwent ECG-gated CCTA by a 64-detector row scanner in our institution. The presence and the location of MB in CCTA images and the presence of atherosclerosis in the tunneling vessels were evaluated and recorded. Major CVD events in the cohort were tracked from the day of CCTA examination until on March 2009 termination of follow-up.
Results: The depiction rate of MB was 20.9% (89/425). A total of 122 MB were depicted by CCTA. Thirty-six tunneling segments (29.5%) were situated in the distal portion of the left anterior descending coronary artery (LAD), 23 segments (18.8%) were in the middle portion of the LAD, 19 (15.5%) were in the first obtuse marginal branch of the left circumflex artery, 18 (14.7%) in the first diagonal branch of the LAD, and 10 (8.1%) were in the ramus medianus. Nine tunneling segments (7.3%) had concomitant atherosclerotic plaques at the time of CCTA. One hundred and nine tunneled segments (89.3%) were superficially located in the myocardium, with a mean depth of 1.9 ± 0.81 mm (range, 0.9−4 mm). Twelve patients with CVD events were recorded during the mean follow-up interval of 21.91 ± 4.03 months (range, 3.08−28.82 months). All 12 patients with CVD events had no MB on CCTA.
Conclusion: The depiction rate of MB by CCTA was 20.9% in this study. The most common location of MB was in the LAD. Concomitant atherosclerotic plaques were found in 7.3% of MB cases. Eighty-nine percent of tunneling vessels were superficially situated. None of the enrolled subjects with MB developed CVD event during the follow-up period. No statistical correlation was found between the presence of MB and CVD event ($p = 0.057$).

Keywords: Coronary anomalies; Coronary computed tomographic angiography; Myocardial bridging; Tunneling vessel

1. Introduction

Myocardial bridging (MB), an inborn coronary artery abnormality, is defined as a segment of a major epicardial coronary artery that goes inwardly through the myocardium beneath the muscle bridge.[1,2] It was first described by Portmann and Iwig[3] by catheter coronary angiography (CAG) in 1960. A

* Corresponding author. Dr. Ming-Huei Sheu, Department of Radiology, Taipei Veterans General Hospital, 201 Section 2, Shih-Pai Road, Taipei 112, Taiwan, ROC.
E-mail address: mhsheu@vghtpe.gov.tw (M.-H. Sheu).

1726-4901/$ - see front matter
doi:10.1016/j.jcma.2011.01.037

"milking" effect and a "step down–step up" phenomenon, caused by systolic compression of the myocardium on the tunneled segment, have been the typical description and regarded as an indirect sign of MB in coronary angiograms.[4] The depiction rate of MB by catheter CAG was 0.5–4.5%.[5,6]

Coronary computed tomographic angiography (CCTA) with ECG-gated technique has emerged as a noninvasive and reliable modality for evaluating coronary artery stenosis and anomalies.[7–12] In contrast to the indirect visualization of MB by catheter CAG, CCTA demonstrates the intramyocardial location of the tunneled artery directly owing to superb tissue discrimination between hypodense myocardium and hyperdense artery. The depiction rate of MB by CCTA is expectedly different from that by catheter CAG.[13,14]

MB had been correlated with some clinical complications of major cardiovascular disease (CVD) including acute myocardial infarction, ventricular arrhythmia, and sudden death in a small number of patients.[15–18] The patient outcome had not been studied well.

The aim of this study was to assess the depiction rate and relevant anatomy of MB by the use of CCTA in a Taiwanese cohort, and to evaluate the cardiovascular outcome of patients with MB.

2. Methods

2.1. Subjects

From September 2006 to December 2007, 573 subjects consecutively underwent CCTA in our institution, either for known or suspected coronary artery disease or self-referral for physical checkup. A written informed consent was obtained. All subjects were informed of the potential radiation hazard and risks of contrast medium administration. Subjects with a history of documented coronary artery stenosis by catheter CAG, percutaneous coronary intervention/stenting, and coronary artery bypass graft were excluded. Inadequate clinical information of cardiovascular illness and loss to follow-up after CCTA examination were also excluded. A total of 425 subjects (264 men and 161 women, mean age 59.6 ± 11.7 years) were enrolled in this retrospective study.

2.2. MDCT scanning protocol

CCTA was performed using a 64-detector row scanner (Aquilion, Toshiba Medical Systems, Tokyo, Japan). The scan parameters were as follows: collimation 64 × 0.5 mm, pitch range 0.2–0.29, increment 0.3 mm, table feed per rotation 7.2 mm, gantry rotation time 350 milliseconds, tube voltage 120–135 KVp, and tube current 400–500 mA (depending on patient size). The scanning range covered from 1 cm below the carina to the cardiac apex. The subjects were instructed to maintain an inspiratory breath-hold during which the CT data and ECG tracing were simultaneously acquired. Heart rate was controlled to below 65 beats/min by the administration of a beta blocker. Scan delay was defined using bolus tracking in the ascending aorta at the level of aortic root, the scan was triggered 6 seconds after reaching the predefined threshold of 150 HU. Contrast enhancement was achieved by using 60–80 mL of nonionic contrast agent with concentration of more than 350 mg I/mL injected at a flow rate of 4–5.5 mL/s through an 18-gauge cannula placed in antecubital vein, and then followed by a 30–40 mL of saline chaser bolus injected at a rate of 4–5 mL/s to washout contrast agent in the right heart and superior vena cava.

2.3. Image processing and data analysis

Axial slice images were reconstructed from the acquired CT data by retrospective ECG-gating method during mid-to-late diastolic phase with reconstruction window positioned at 75% of R-R interval. Additional temporal window positions were explored, including the end-systolic phase at 40% of R-R interval, to obtain images with the least motion artifact as anticipated.

The axial images of best phase were processed at workstations, a Vitrea workstation (Toshiba Medical Systems, Tochigi, Japan) and an Aquarius workstation (TeraRecon, San Mateo, CA, USA), to create multiplanar reconstruction (MPR), curved multiplanar reconstruction (curved MPR), and volume-rendering technique images. Orthogonal view (trans-axial view) of the coronary arteries was obtained during curved MPR. Multiplanar and curved planar reformations were used for depiction of MB in at least two planes: one parallel and one perpendicular to the course of the vessel.

Image quality was determined by two experienced radiologists in consensus on the presence of motion artifacts and signal-to-noise ratio, and was classified into four scales. Excellent imaging quality showed no motion artifacts. Good imaging quality had minor artifacts, but did not interfere with diagnosis. Fair imaging quality had moderate artifacts or blurring, but was still adequate for diagnosis. Poor imaging quality had severe artifacts that made vessel delineation technically difficult or impossible. Only images of excellent, good, and fair quality were included for further analysis.

MB was defined as wherever part of a coronary artery was found to be completely surrounded by the myocardium (Fig. 1). The classification system of the American Heart Association was used for coronary artery nomenclature.[19]

The length of tunneling vessels was determined by curved MPR images. The depth and luminal diameter of tunneling vessels were measured on planes perpendicular to the course of the vessel. MB was categorized into superficial and deep type, as described by previous report.[20]

2.4. Patients outcome follow-up

Major CVD event was defined as the occurrence of documented acute myocardial infarction, ventricular arrhythmia, received percutaneous coronary intervention/stenting, coronary artery bypass graft, or CVD-related death. Major CVD after CCTA study was reviewed from medical records, mortality records from the Department of Health, and from patient or family by telephone interview. Follow-up of CVD

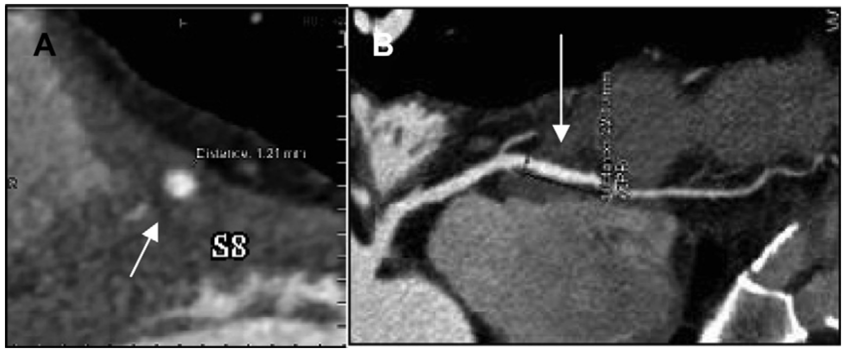

Fig. 1. Myocardial bridging in the distal left anterior descending coronary artery (arrow). (A) Curved multiplanar reconstruction and transaxial view; (B) curved multiplanar reconstruction and longitudinal view. Depth of myocardial bridging is 1.21 mm and length 22 mm.

events commenced on the day of CCTA examination and terminated March 2009, or on the day a CVD event occurred.

2.5. Statistical analysis

Statistical analysis was performed using commercially available software (SPSS 13.0 for Windows; SPSS Inc., Chicago, IL, USA). A two-tailed test with $p < 0.05$ was considered statistically significant. Mean ± standard deviation was used for expressing continuous variables. Data in the parentheses represent minimal and maximal values. For comparing the incidence of two groups, the χ^2 test was applied. If the expected number was less than 5 in any cell, Fisher's exact test was used instead.

3. Results

The imaging quality of coronary CT angiograms was graded as excellent, good, or fair in all of the 425 subjects. No study was regarded as nonevaluable.

Of 425 enrollees, 89 were found to have MB. The CCTA depiction rate of MB was 20.9% (89/425). Demographic data and risk factors of atherosclerosis in the patients having MB are shown in Table 1. Mean age of the patients having MB was 57.4 ± 16.1 years. The depiction rate of MB was 25.7% (68/264) in men and 13% (21/161) in women.

A total of 122 segments of tunneling vessel were found in the 89 subjects, the locations of tunneling segments are shown in Table 2. The most common site of MB was the distal left anterior descending coronary artery (LAD) (29.5%), followed by the middle LAD (18.8%), and the first obtuse marginal branch of the left circumflex artery (15.5%). The length of the tunneling vessels was a mean 21.4 ± 9.6 mm, ranged from 5.5 mm to 48 mm. The depth of the tunneling vessels ranged from 0.9 mm to 15 mm (mean, 2.55 ± 9.6 mm). The minimum luminal diameter of the tunneling vessels was a mean 2.32 ± 0.56 mm, ranged from 1.2 mm to 3.8 mm (Table 2). There was no statistical correlation between the length, depth, or minimal luminal diameter of the tunneling vessels and the presence of chest distress-related symptoms on presentation ($p = 0.428$, $p = 0.089$, and $p = 0.081$, respectively). Nine tunneling segments (7.3%) had concomitant atherosclerotic plaque (Fig. 2). One hundred and nine tunneling segments (89.3%) were superficially located in the myocardium, with a mean depth of 1.9 ± 0.81 mm (range, 0.9−4 mm); 13 segments with deeper MB were located in the first and second diagonal branch of the LAD, the first obtuse marginal branch of the left circumflex artery, and ramus medianus; the mean depth of the deeper MB was 8.05 ± 3.9 mm (range, 5.3−15 mm).

Twelve patients with CVD events were recorded from the post-CCTA date up to March 2009. The mean duration of

Table 1
Demographic and clinical characteristics in patients having myocardial bridging[a]

Number of patients	89
Age (yr)	57.4 ± 16.1
Female (%)	21 (23.7)
BMI (kg/m^2)	25.3 ± 3.6
Hypertension	53 (59.5)
Diabetes mellitus	16 (17.9)
Hyperlipidemia	40 (44.9)
Current smoking	12 (13.4)
Chest distress on presentation	59 (66.2)

[a] Data are presented as *n*, mean ± standard deviation or *n*(%).
BMI = body mass index.

Table 2
Location of myocardial bridging and characteristics of tunneling vessels[a]

Location	
Posterior descending artery	3 (2.4)
Proximal LAD	2 (1.6)
Middle LAD	23 (18.8)
Distal LAD	36 (29.5)
First diagonal branch	18 (14.7)
Second diagonal branch	6 (4.9)
First obtuse marginal branch	19 (15.5)
Distal LCX	2 (1.6)
Posterior left ventricular branch	3 (2.4)
Ramus medianus	10 (8.1)
Length of tunneling vessel (mm)	21.4 ± 9.6 (5.5−48)
Depth of tunneling vessel (mm)	2.55 ± 1.21 (0.9−15)
Minimum luminal diameter (mm)	2.32 ± 0.56 (1.2−3.8)

[a] Data are presented as *n*(%) or mean ± standard deviation (range).
LAD = left anterior descending coronary artery; LCX = left circumflex artery.

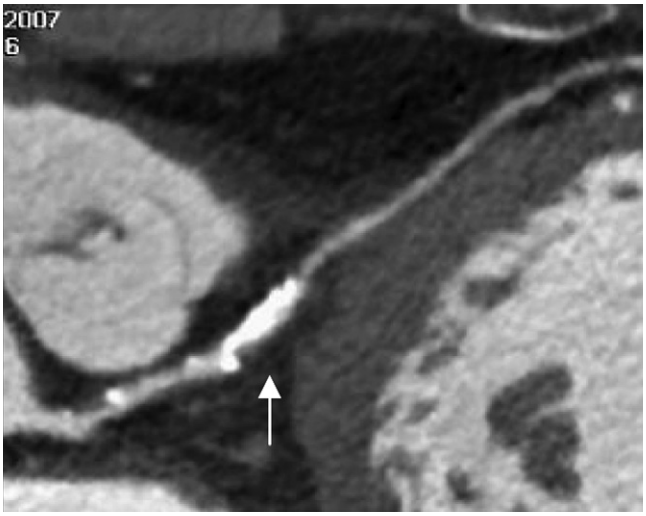

Fig. 2. Myocardial bridging in the middle left anterior descending coronary artery, concomitant atherosclerotic plaques (arrow) are depicted proximal to the tunneling segment.

follow-up was 21.91 ± 4.03 months (range, 3.08–28.82 months); none of the patients with CVD events had MB on CCTA. The prevalence of CVD events is shown in Table 3. There was no statistical correlation between the presence of MB and the occurrence of CVD event ($p = 0.057$).

4. Discussion

CAG has been the most common modality for the imaging diagnosis of MB in the pre-MDCT (multi-detector rows CT) era.[21] Interpretation of angiography requires experienced eyes, and only the deep type of bridges appears conspicuous on angiography.[22]

The reported depiction rate of MB varies in autopsy and in catheter CAG studies. Autopsy reports have found a mean depiction rate of 25 percent,[4,5,18,23] which is regarded as a reference standard. A 0.5–4.5% of depiction rate by catheter CAG studies was reported,[5,6] remarkably lower than the reference standard.

The depiction rate of MB in this Taiwanese cohort performed with CCTA was 20.9%. This result is higher than that of catheter CAG studies in the literature,[5,6] and also exceeds that of our previous study using 16-detector row MDCT.[24] This is still lower than the reference standard of autopsy studies. Further investigations with newer generation CT scanners equipped with higher spatial resolution are called for to address refinements of MB depiction.

Table 3
Occurrence of cardiovascular events

Events	*n*
Unstable angina	3
CABG	1
PCI/coronary stenting	8
Total	12

CABG = coronary artery bypass graft; PCI = percutaneous coronary intervention.

MB predisposes to the development of atherosclerosis in the coronary artery segment proximal to the bridge.[24,25] Increased wall shear stress and/or exposure to epicardial fat in these segments are thought to be predisposing factors for the development of atherosclerosis,[26,27] whereas tunneling vessels lacking epicardial fat are protected against the development of atherosclerosis.[27] In our study, nine tunneling segments had concomitant atherosclerotic plaques, three segments were located in the LAD and associated with insignificant luminal stenosis.

MB of coronary arteries has long been an incidental finding in autopsy studies. Evidence in the literature documenting its association with clinical presentations of acute myocardial infarction and unstable angina are ascribed to compromised coronary flow in the left anterior descending artery.[15–17] However, discrepant to other reports, there was no documented CVD event of unstable angina or acute myocardial infarction in all of the 89 subjects having tunneled vessels in our study. Superficial- type MB was depicted in 89% of cases (109/122), and included 61 segments situated in the LAD. Superficially located tunneling vessel, which suffered less extrinsic compression during the systolic phase of the cardiac cycle than did deep bridging,[20] probably accounted for the discrepancy of CVD events between previous reports and this study. Exercise-induced ventricular tachycardia and atrioventricular conduction block,[15,18,28,29] or sudden death[18,30] were also not documented in our cohort. The pathogenesis of CVD events in patients having MB, beside coronary flow compromise, is probably multifactorial[31] and deserves further study.

The main drawback of CCTA is the radiation dose. This is currently in the range of 10–15 mSv, double the dose of a catheter CAG.[32] Fortunately, most of the patients having CCTA scanning are 60 years old, and theoretically it would take another 10–20 years before any radiation-induced cancer might develop.[33] For younger patients, the lower the radiation dose, the better. Radiation dose can be significantly reduced with some dose-saving modulations or using newer generation scanners, not compromising diagnostic imaging quality.[34,35]

There are limitations in this study with regard to study design. First, our focus was on detecting the prevalence rate of MB and identifying its anatomical location, therefore, we only used data images in the diastolic phase of the cardiac cycle. Unfortunately, it is generally not possible to evaluate the anatomical aspects of MB in systole and to measure the hemodynamic changes of MB at heart rate <65 beats/min at the level of 64-slice MDCT. Secondly, our results, being that from a single institution, may not truly represent the status in the general population. Thirdly, there was no exercise test or stress myocardial perfusion imaging to explore the relationship between ischemia symptoms and MB by MDCT findings. Furthermore, the post-CCTA follow-up period for CVD event was limited to intermediate-term observation because of study design. Further studies on larger cohort and long-term follow-up are required to confirm these results.

In conclusion, we assessed the depiction rate of MB in a Taiwanese cohort by CCTA. The location of MB and concomitant atherosclerosis of the tunneling vessels, and CVD outcome in patients with MB were evaluated. Our study disclosed the depiction rate of MB was 20.9% by CCTA, higher than the depiction rate of MB by catheter CAG reported in the literature. The most common location of MB was in the LAD. About 89% of the tunneling vessels were superficial type, and 7% of the MB had concomitant atherosclerosis. There was no correlation between the presence of MB and the occurrence of CVD event in this study.

References

1. Angelini P, Velasco JA, Flamm S. Coronary anomalies: incidence, pathophysiology, and clinical relevance. *Circulation* 2002;**105**:2449—54.
2. Angelini P, Trivellato M, Donis J, Leachman RD. Myocardial bridges: a review. *Prog Cardiovasc Dis* 1983;**26**:75—88.
3. Porstmann W, Iwig J. Intramural coronary vessels in the angiogram. *Fortschr Geb Rontgenstr Nuklearmed* 1960;**92**:129—33 [in German].
4. Mohlenkamp S, Hort W, Ge J, Erbel R. Update on myocardial bridging. *Circulation* 2002;**106**:2616—22.
5. 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**:993—9.
6. Rossi L, Dander B, Nidasio GP, Arbustini E, Paris B, Vassanelli C, et al. Myocardial bridges and ischemic heart disease. *Eur Heart J* 1980;**1**:239—45.
7. 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**:335—7.
8. Ropers D, Baum U, Pohle K, Anders K, Ulzheimer S, Ohnesorge B, et al. Detection of coronary artery stenoses with thin-slice multi-detector row spiral computed tomography and multiplanar reconstruction. *Circulation* 2003;**107**:664—6.
9. Nieman K, Rensing BJ, van Geuns RJ, Munne A, Ligthart JM, Pattynama PM, et al. Usefulness of multislice computed tomography for detecting obstructive coronary artery disease. *Am J Cardiol* 2002;**89**:913—8.
10. Kopp AF, Schroeder S, Kuettner A, Baumbach A, Georg C, Kuzo R, et al. Non-invasive coronary angiography with high resolution multidetector-row computed tomography: results in 102 patients. *Eur Heart J* 2002;**23**:1714—25.
11. Sheu MH. Coronary computed tomography angiography-noninvasive modality in assessing coronary artery disease. *J Chin Med Assoc* 2008;**71**:232—3.
12. Han SC, Fang CC, Chen Y, Chen CL, Wang SP. Coronary computed tomography angiography: a promising imaging modality in diagnosing coronary artery disease. *J Chin Med Assoc* 2008;**71**:241—6.
13. La Grutta L, Runza G, Lo Re G, Galia M, Alaimo V, Grassedonia E, et al. Prevalence of myocardial bridging and correlation with coronary atherosclerosis studied with 64-slice CT coronary angiography. *Radiol Med* 2009;**114**:1024—36.
14. Kim SY, Lee YS, Lee JB, Ryu JK, Choi JY, Chang SG, et al. Evaluation of myocardial bridge with multidetector computed tomography. *Circ J* 2010;**74**:137—41.
15. Chee TP, Jensen DP, Padnick MB, Cornell WP, Desser KB. Myocardial bridging of the left anterior descending coronary artery resulting in subendocardial infarction. *Arch Intern Med* 1981;**141**:1703—4.
16. Morales AR, Romanelli R, Boucek RJ. The mural left anterior descending coronary artery, strenuous exercise and sudden death. *Circulation* 1980;**62**:230—7.
17. Bestetti RB, Costa RS, Zucolotto S, Oliveira JS. Fatal outcome associated with autopsy proven myocardial bridging of the left anterior descending coronary artery. *Eur Heart J* 1989;**10**:573—6.
18. Alegria JR, Herrmann J, Holmes Jr DR, Lerman A, Rihal CS. Myocardial bridging. *Eur Heart J* 2005;**26**:1159—68.
19. Austen WG, Edwards JE, Frye RL, Gensini GG, Gott VL, Griffith LS, et al. A reporting system on patients evaluated for coronary artery disease. Report of the Ad Hoc Committee for Grading of Coronary Artery Disease, Council on Cardiovascular Surgery, American Heart Association. *Circulation* 1975;**51**:5—40.
20. Ferreira Jr A, Trotter SE, Konig Jr B, Decourt LV, Fox K, Olsen EG. Myocardial bridges: morphological and functional aspects. *Br Heart J* 1991;**66**:364—7.
21. Irvin RG. The angiographic prevalence of myocardial bridging in man. *Chest* 1982;**81**:198—202.
22. Dominguez B, Valderrama V, Arrocha R, Lombana B. Myocardial bridging as a cause of coronary insufficiency. *Rev Med Panama* 1992;**17**:28—35 [in Spanish].
23. Stolte M, Weis P, Prestele H. Muscle bridges over the left anterior descending coronary artery: their influence on arterial disease. *Virchows Arch A Pathol Anat Histol* 1977;**375**:23—36 [in German].
24. Chen YD, Wu MH, Sheu MH, Chang CY. Myocardial bridging in Taiwan: depiction by multidetector computed tomography coronary angiography. *J Formos Med Assoc* 2009;**108**:469—74.
25. Feld H, Guadanino V, Hollander G, Greengart A, Lichstein E, Shani J. Exercise-induced ventricular tachycardia in association with a myocardial bridge. *Chest* 1991;**99**:1295—6.
26. den Dulk K, Brugada P, Braat S, Heddle B, Wellens HJ. Myocardial bridging as a cause of paroxysmal atrioventricular block. *J Am Coll Cardiol* 1983;**1**:965—9.
27. Bestetti RB, Costa RS, Kazava DK, Oliveira JS. Can isolated myocardial bridging of the left anterior descending coronary artery be associated with sudden death during exercise? *Acta Cardiol* 1991;**46**:27—30.
28. Zeina AR, Odeh M, Blinder J, Rosenschein U, Barmeir E. Myocardial bridge: evaluation on MDCT. *AJR Am J Roentgenol* 2007;**188**:1069—73.
29. Bennett JM, Blomerus P. Thallium-201 scintigraphy perfusion defect with dipyridamole in a patient with a myocardial bridge. *Clin Cardiol* 1988;**11**:268—70.
30. Sacks HS, Fain JN. Human epicardial adipose tissue: a review. *Am Heart J* 2007;**153**:907—17.
31. Kim JW, Seo HS, Na JO, Suh SY, Choi CU, Kim EJ, et al. Myocardial bridging is related to endothelial dysfunction but not to plaque as assessed by intracoronary ultrasound. *Heart* 2008;**94**:765—9.
32. Coles DR, Smail MA, Negus IS, Wilde P, Oberhoff M, Karsch KR, et al. Comparison of radiation doses from multislice computed tomography coronary angiography and conventional diagnostic angiography. *J Am Coll Cardiol* 2006;**47**:1840—5.
33. Brenner DJ, Elliston CD. Estimated radiation risks potentially associated with full-body CT screening. *Radiology* 2004;**232**:735—8.
34. Hausleiter J, Meyer T, Hadamitzky M, Huber E, Zankl M, Martinoff S, et al. Radiation dose estimates from cardiac multislice computed tomography in daily practice: impact of different scanning protocols on effective dose estimates. *Circulation* 2006;**113**:1305—10.
35. Deetjen A, Mollmann S, Conradi G, Rolf A, Schmermund A, Hamm CW, et al. Use of automatic exposure control in multislice computed tomography of the coronaries: comparison of 16-slice and 64-slice scanner data with conventional coronary angiography. *Heart* 2007;**93**:1040—3.