Prevalence and predictors of bridging of coronary arteries in a large Indonesian population, as detected by 64-slice computed tomography scan

J. Wirianta · M. Mouden · J. P. Ottervanger ·
J. R. Timmer · Y. B. Juwana · M.-J. de Boer ·
H. Suryapranata

Published online: 6 July 2012
© Springer Media / Bohn Stafleu van Loghum 2012

Abstract

Background Multislice computed tomography (MSCT) can be used to detect myocardial bridging (MB) of coronary arteries. However, most published studies included small cohorts and did not collect data about predictors. We investigated prevalence and predictors of MB in an Indonesian population.

Methods All patients who had MSCT at Cinere Hospital, Jakarta, Indonesia between 2006 and 2009 were included in a prospective registry. MB was defined when at least half of the coronary artery was imbedded within the myocardium with a normal epicardial course of the proximal and distal portion.

Results Of the 934 patients (mean age 53 years, 37.8 % female), MB could be observed in 152 patients (16.3 %). Patients with MB were younger compared with those without MB. Coronary risk factors were not different between the two groups. Coronary calcifications and moderate to severe coronary stenoses were less prevalent in patients with MB, also after adjusting for differences in age. At the time

of diagnosis, only a few patients with MB were treated with beta-blockers (35 %) or calcium channel blockers (13 %).

Conclusions Prevalence of myocardial bridging as detected by MSCT is relatively high. Patients with MB were younger and had a lower prevalence of coronary sclerosis. MB could be the cause of their unexplained symptoms. Follow-up studies are necessary to assess the symptoms of these patients, their response to treatment and the incidence of (coronary) events. MSCT can be used to identify patients for potential new treatment strategies.

Keywords Myocardial bridging · Prevalence · Non-invasive imaging · Coronary abnormalities · Multislice computed tomography

Introduction

Although mortality and morbidity of coronary artery disease is usually caused by atherosclerotic processes, congenital anomalies of coronary arteries may also cause symptoms in a subset of patients. Myocardial bridging (MB) of coronary arteries is caused by muscles overlying the intramyocardial course of an epicardial coronary artery. It is characterised by systolic compression of the tunnelled segment, commonly affecting the mid-portion of the left anterior descending coronary artery (LAD). Although, in general, MB is a benign condition, it may cause symptoms as chest pain and has been associated with impairment in endothelium-dependent vasorelaxation [1] and clinical events such as myocardial infarction [2]. The deep intramural LAD has even been associated with sudden death [3].

Previously, the diagnosis of MB was made by coronary angiography with a typical angiographic ‘milking effect’.

M. Mouden · J. P. Ottervanger (✉) · J. R. Timmer ·
H. Suryapranata
Department of Cardiology, Isala Klinieken,
Groot Wezenland 20,
8011 JW Zwolle, the Netherlands
e-mail: v.r.c.derks@isala.nl

J. Wirianta · Y. B. Juwana
Department of Cardiology, Cinere Hospital,
Jl. Maribaya No 1, Puri Cinere,
Depok 16514 Jakarta, Indonesia

M.-J. de Boer · H. Suryapranata
Department of Cardiology, University Medical Centre Nijmegen,
Geert Grooteplein 10,
6525 GA Nijmegen, the Netherlands

Also intravascular ultrasound (IVUS) and intracoronary Doppler (ICD) can be helpful in diagnosing the severity of MB [4]. Interestingly, IVUS studies have shown that despite the strong association between MB and endothelial dysfunction, bridging segments are relatively spared from atherosclerotic plaque formation [5]. However, non-invasive imaging may detect the existence of MB even better than coronary angiography with lower risks for general patients [6, 7]. Although there are now several publications on MB in patients who underwent multislice computed tomography (MSCT) of the heart, most studies had a small sample size (<300–400). Furthermore, most studies did not collect data on predictors or risk factors [8, 9]. Data about prevalence and predictors in an Indonesian population are not available. The aim of our study was to assess the prevalence and predictors of MB in a large cohort of consecutive patients who had undergone coronary MSCT at a non-university hospital in Indonesia.

Methods

All consecutive patients who were referred to our hospital for non-invasive angiography of coronary arteries by MSCT for suspected or known coronary artery disease were eligible for this prospective registry. At baseline, eligible patients completed a questionnaire on current medication use and risk factors for coronary artery disease. Height, weight, blood pressure and pulse were measured. In addition, data on treadmill ECG stress testing performed before the MSCT examination were collected when available.

MSCT imaging

A beta-blocker was administered to all patients with a heart rate over 65 beats/min (metoprolol 100 mg orally or 5 to 10 mg intravenously, 1 hour or immediately before scanning, respectively). A coronary computed tomographic angiography was obtained with a 64-slice multidetector CT scanner (Brilliance 64, Philips Medical Systems). Non-enhanced MSCT for calcium scoring was performed from 1 cm below the level of the tracheal bifurcation to the diaphragm in a craniocaudal direction. Contrast medium (Iopamiro 370/100 ml) was injected intravenously at a rate of 5–6 ml/s.

MSCT analysis

The cardiac MSCT data were analysed by an experienced cardiologist at the site (JW) and independently also by second investigators. If the diagnoses were different, the pictures were re-assessed. Disagreement was solved by a consensus reading.

The calcium scoring study was evaluated using an established analysis program (Heartbeat-CS, EBW, Philips Medical Systems). Agatston scores were determined and recorded on case report forms. Using retrospective electrocardiographic gating, reconstructions were performed routinely at 75 % phases of the R-R interval period. Depending on the coronary morphology and quality of the scan other phases were applied to assess the coronary arteries. Analysis of scans was performed on a dedicated workstation (Philips Extended Brilliance Workspace). The dataset was evaluated in terms of contrast opacification, assessability, stenoses and plaques. Coronary arteries were assessed using axial and multiplanar reconstructions. Coronary stenosis was graded according to severity. Coronary stenosis was defined as absent (no coronary stenosis), mild stenosis (<40 %), moderate stenosis (40–70 %) and severe stenosis (>70 %).

MB was defined when at least half of the coronary arterial diameter was imbedded within the myocardium and with the proximal and distal portions of the coronary artery coursing through epicardial fat. Arterial segments located in a deep gorge but covered only by a thin layer of muscle or fibrous-fatty tissue were included because it was reported that they may also be compressed during systole by the surrounding muscle. The length and depth of the MB was measured: depth was defined as the diameter of the coronary artery in the MB plus the muscle width.

Statistical analysis

Statistical analysis was performed with the Statistical Package for the Social Sciences (SPSS Inc., Chicago, IL, USA) version 15.0.1). Continuous data were expressed as mean $\pm$ standard deviation and categorical data as percentage, unless otherwise denoted. Differences between continuous data were performed by Student's *t*-test and the chi-square or Fisher's exact test were used as appropriate for dichotomous data. Binary logistic regression analysis was performed to test the independent association between several characteristics and MB. Analysed variables that were significant are reported with their respective odd ratios and 95 % confidence intervals. For all analyses, statistical significance was assumed when the two-tailed probability value was <0.05.

Results

During the study period, a total of 934 patients were referred to our hospital for cardiac MSCT imaging. Mean age was 53 years (range 23–82), 37.8 % were female and 13.4 % had diabetes. Mean systolic blood pressure before MSCT was 132 mmHg ($\pm$ 18.4) and mean diastolic blood pressure 82 mmHg ($\pm$ 10.7). Beta-blockers were used by 43 % of patients and 13 % of the patients used calcium antagonists.

MB could be observed in 152 patients (16.3 %). The distribution of the coronary location of MB is listed in Table 1. The majority of MB was located in the LAD, particularly in the mid-LAD. There were no patients with MB of the right coronary artery (RCA).

Differences between patients with and without MB are summarised in Table 2. Patients with MB were younger than those without MB. There were no differences in traditional coronary risk factors, including diabetes, smoking, dyslipidaemia and hypertension, between patients with and without MB. The clinical symptoms were comparable between the two patient groups. There were significant differences in the prevalence of atherosclerosis between patients with and without MB. Coronary sclerosis as assessed by coronary calcification was less prevalent in patients with MB and the presence of moderate to severe coronary stenoses was also significantly lower in this patient group (Table 2 and Table 3). After adjustments for age, MB was still strongly associated with a lower prevalence of moderate to severe coronary stenoses (HR 0.37; CI 95 %: 0.22–0.61, $p<0.001$).

Of the 934 patients, 668 (72 %) underwent treadmill ECG stress testing because of suspected coronary artery disease prior to referral for non-invasive coronary angiography by MSCT, of whom 181 (27 %) had a positive ECG stress test. Treadmill ECG stress test was positive for ischaemia in 34 of 119 patients (29 %) with MB compared with 147 of 549 patients (27 %) without MB ($p=0.69$).

Discussion

In this large cohort, it is demonstrated that MSCT is an easy and reliable tool for comprehensive in vivo diagnosis of the intramuscular course of coronary arteries. We found a prevalence of MB as detected by MSCT of 16.3 %. Patients with MB were younger than those without MB. There were no

Table 1 Coronary location of myocardial bridging in 152 patients as measured by 64-slice MSCT

	Location of bridging % (N=152)*
Proximal LAD	13.2
Mid LAD	77.6
Distal LAD	9.2
Proximal RCX	0.7
Mid RCX	2.6
Distal RCX	2.6
RCA	0
Intermediate Branch	2

* some patients had MB at more locations

LAD left anterior descending coronary artery, RCX ramus circumflexus, RCA right coronary artery

Table 2 Differences between patients with and without bridging as measured by 64-slice MSCT

	Without bridging N=782	With bridging N=152	P value
Age (years)	53.6±11.0	51.3±9.3	0.015
BMI	25.9±4.1	25.9±3.8	0.89
Male	63%	60%	0.62
Systolic blood pressure (mmHg)	132±18	129±19	0.08
Diastolic blood pressure (mmHg)	82±10	81±12	0.81
Diabetes	13.5%	13.2%	0.91
Family history of heart disease	35%	37.5%	0.57
High lipids	44%	51%	0.09
Hypertension	28%	24%	0.29
Smoking	21%	16%	0.18
Complaints for referral			
- Atypical chest pain	46%	40%	0.21
- Dizziness	7.3%	4.3%	0.24
- Dyspnoea	9.9%	10.7%	0.79
- Palpitations	10.6%	9.2%	0.64
- Typical chest pain	18.5%	21.8%	0.40
Medication			
- Beta-blocker	44.6%	35%	0.05
- Calcium channel blocker	19%	13%	0.11
Total calcium score	152±423	127±769	0.57
Calcium score=zero	50%	62%	0.007
Calcium score >400	11%	3%	0.003
Moderate/severe stenosis	34.0%	14.7%	<0.001

differences in coronary risk factors or stress testing results between patients with and without MB, but the prevalence of coronary artery disease was higher. After adjustments for differences in age, patients with MB still had less coronary stenoses.

Previous studies

The estimated frequency that has been reported varies from 1.5 to 16 % when assessed by coronary angiography, but in some autopsy series, it is as high as 80 % [10, 11]. Kramer et al. reviewed 658 normal coronary angiograms of patients with normal left ventricular function and found that 81 (12 %) had a myocardial bridge of the LAD [12]. In a larger study, assessing 7467 consecutive coronary angiograms, only 61 (<1%) of the patients had a myocardial bridge of the LAD [13].

A few studies investigated the association between traditional coronary angiography and MSCT in detecting MB [6,

Table 3 Percentage of moderate and severe stenosis in patients with and without bridging as measured by 64-slice CT scan

	Without bridging <i>N</i> =782	With bridging <i>N</i> =152	P value
LAD			0.001
- Moderate stenosis	22.4	7.9	
- Severe stenosis	6.7	2.6	
RCX			0.06
- Moderate stenosis	7.7	4.6	
- Severe stenosis	2.4	0.7	
RCA			0.008
- Moderate stenosis	9.2	5.3	
- Severe stenosis	5.3	1.3	

LAD left anterior descending coronary artery, *RCX* ramus circumflexus, *RCA* right coronary artery

7, 14]. It was shown that the diagnosis of MB was more often made with MSCT, suggesting that MSCT is superior to traditional angiography although differences in the definition of MB may play a role. With MSCT, different prevalences of MB have been reported (Table 4), ranging from 5.7% tot 33% [6–8, 14–32].

We did not find MB in the RCA in any of our patients. Although MB of RCA has been described [33], it is probably very rare.

Myocardial bridging and coronary lesions

In our study, the number of stenoses in the different coronary arteries was lower in patients with MB. There may be several explanations for these findings. Patients with MB were younger. However, after correction for age the association between bridging and a lower prevalence of coronary artery disease remains evident. Another explanation might be that MB was responsible for chest pain complaints, which led to the decision to perform a coronary MSCT. In patients without MB, coronary artery disease as a cause for chest pain is more likely. An alternative explanation could be that MB might be protective for the development of coronary artery disease. Several pathology studies have been performed assessing the extent of atherosclerosis, particularly within the bridge, in patients with MB [34]. Altogether, the data suggest that MB is associated with the decreased development of atherosclerosis under and proximal to the tunnelled artery, although it is unclear whether this is an independent factor [35]. It seems that MB located within 5 cm from the left coronary ostium may prevent atherosclerosis in the proximal part of LAD [36].

Myocardial bridging and stress testing

Although several prior studies have assessed the frequency of MB detected by invasive angiography and MSCT, only limited data are available describing the relationship between MB and non-invasive stress test results. In our study, 29% of the patients with MB had a positive exercise stress test, which is in line with previous work by Bourassa et al. [37], who reported ischaemic ECG findings in 28–67%. However, higher rates were found by others, especially in the presence of left ventricular hypertrophy or severely bridged coronary segments [38, 39].

Treatment

It may be difficult to decide what to do with patients with MB as diagnosed by MSCT, particularly if they have symptoms. In general, therapeutic approaches that have been attempted for myocardial bridging include beta-blockers, calcium channel blockers, stents, coronary artery bypass grafting (CABG), percutaneous coronary interventions (PCI) and surgical myotomy. In a small study (*n*=29), it was shown that coronary stent placement for medically refractory symptomatic myocardial bridging failed to relieve

Table 4 Prevalence of myocardial bridging as reported in different MSCT studies

First author (reference)	Number of patients	Prevalence (%)
Leschka (6)	150	28.7
Lu (7)	53	30.2
De Rosa (8)	242	18.7
Lubarsky (9)	300	33
Kim (14)	311	58.0
Cademartiri (15)	543	10.9
Ko (16)	401	5.7
Konen (17)	118	30.5
Kawawa (18)	148	15.8
Johansen (19)	152	32.2
Jacobs (20)	506	10.5
Wang (21)	51	54.9
Duran (22)	725	4.0
Kantarci (23)	626	3.5
La Grutta (24)	254	28.7
Hwang (25)	1275	42.0
Koşar (26)	700	37.0
La Grutta (27)	277	29.6
Rodríguez-Granillo (28)	577	17.3
Liu (29)	3011	5.8
Atar (30)	169	17
Kim (31)	607	6
Chen (32)	276	8.7

severe angina and was associated with high clinical restenosis [40]. In emergency situations, as in patients with myocardial infarction due to occlusion of the coronary vessel at the site of MB, percutaneous coronary intervention can be performed [41]. Nitrates should be avoided because they may increase the angiographic degree of systolic narrowing and can lead to worsening of the symptoms. Until now, no specific treatments have been proven to be beneficial in randomised controlled trials. It is possible that now more patients have a diagnosis of MB, as demonstrated by non-invasive imaging, randomised controlled trials will be performed with as endpoint both clinical events and symptoms.

Limitations

We have no follow-up data of our patients and did not perform routine invasive coronary angiography. We have no specific data with regard to the location of coronary stenosis in relation to the location of myocardial bridging. Furthermore, the presence of inducible ischaemia on myocardial perfusion imaging was not assessed and we did not study the relationship between the depth of the bridges and the severity of complaints. Although we describe a large cohort, we could not perform subgroup analyses, such as in females or those with hypertension.

Conclusions

MSCT offers a good possibility to diagnose MB. The prevalence is about 16%. Patients with MB may appear to have a lower prevalence of coronary stenosis, but this should be confirmed in other studies. Also, follow-up studies should be performed to find subsets of patients with MB who are at risk of complications. Finally, randomised controlled trials are necessary to assess which treatment should be given.

Acknowledgments We thank Lia Lorrya Tamangkoa and Dyah Ayu Mawarti, radiographers, for collecting data.

References

- Herrmann J, Higano ST, Lenon RJ, et al. Myocardial bridging is associated with alteration in coronary vasoreactivity. *Eur Heart J*. 2004;23:2134–42.
- Alegria JR, Herrmann J, Holmes DR, et al. Myocardial bridging. *Eur Heart J*. 2005;26:1159–68.
- Morales AR, Romanelli R, Tate LG, et al. Intramural left anterior descending coronary artery: significance of the depth of the muscular tunnel. *Hum Pathol*. 1993;24:693–701.
- Ge J, Jeremias A, Rupp A, et al. New signs characteristic of myocardial bridging demonstrated by intracoronary ultrasound and Doppler. *Eur Heart J*. 1999;23:1707–16.
- Kim JW, Seo HS, Na JO, et al. Myocardial bridging is related to endothelial dysfunction but not to plaque as assessed by intracoronary ultrasound. *Heart*. 2008;94:765–9.
- 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;246:754–62.
- Lu GM, Zhang LJ, Guo H, et al. Comparison of myocardial bridging by dual-source CT with conventional coronary angiography. *Circ J*. 2008;72:1079–85.
- De Rosa R, Sacco M, Tedeschi C, et al. Prevalence of coronary artery intramyocardial course in a large population of clinical patients detected by multislice computed tomography coronary angiography. *Acta Radiol*. 2008;49:895–901.
- Lubarsky L, Gupta MP, Hecht HS. Evaluation of myocardial bridging of the left anterior descending coronary artery by 64-slice multidetector computed tomographic angiography. *Am J Cardiol*. 2007;100:1081–2.
- Geirenger E. The mural coronary. *Am Heart J*. 1951;41:359–68.
- Rossi L, Dander B, Nidasio GP, et al. Myocardial bridges and ischemic heart disease. *Eur Heart J*. 1980;1:239–45.
- Kramer JR, Kitazume H, Proudfit WL, et al. Clinical significance of isolated coronary bridges: benign and frequent condition involving the left anterior descending artery. *Am Heart J*. 1982;103:283–8.
- Juilliere Y, Berder V, Suty-Selton C, et al. Isolated myocardial bridges with angiographic milking of the left anterior descending coronary artery: a long-term follow-up study. *Am Heart J*. 1995;129:663–5.
- Kim PJ, Hur G, Kim SY, et al. Frequency of myocardial bridges and dynamic compression of epicardial coronary arteries. A comparison between computed tomography and invasive coronary angiography. *Circulation*. 2009;119:1408–16.
- Cademartiri F, La Grutta L, Malagò R, et al. Prevalence of anatomical variants and coronary anomalies in 543 consecutive patients studied with 64-slice CT coronary angiography. *Eur Radiol*. 2008;18:781–91.
- Ko SM, Choi JS, Nam CW, et al. Incidence and clinical significance of myocardial bridging with ECG-gated 16-row MDCT coronary angiography. *Int J Cardiovasc Imaging*. 2008;24:445–52.
- Konen E, Goitein O, Sternik L, et al. The prevalence and anatomical patterns of intramuscular coronary arteries: a coronary computed tomography angiographic study. *J Am Coll Cardiol*. 2007;49:587–93.
- Kawawa Y, Ishikawa Y, Gomi T, et al. Detection of myocardial bridge and evaluation of its anatomical properties by coronary multislice spiral computed tomography. *Eur J Radiol*. 2007;61:130–8.
- Johansen C, Kirsch J, Araoz P, et al. Detection of myocardial bridging by 64-row computed tomography angiography of the coronaries. *J Comput Assist Tomogr*. 2008;32:448–51.
- Jacobs JE, Bod J, Kim DC, et al. Myocardial bridging: evaluation using single- and dual-source multidetector cardiac computed tomographic angiography. *J Comput Assist Tomogr*. 2008;32:242–6.
- Wang MH, Sun AJ, Qian JY, et al. Myocardial bridging detection by non-invasive multislice spiral computed tomography: comparison with intravascular ultrasound. *Chin Med J (Engl)*. 2008;121:17–21.
- Duran C, Kantarci M, Durur Subasi I, et al. Remarkable anatomic anomalies of coronary arteries and their clinical importance: a multidetector computed tomography angiographic study. *J Comput Assist Tomogr*. 2006;30:939–48.
- Kantarci M, Duran C, Durur I, et al. Detection of myocardial bridging with ECG-gated MDCT and multiplanar reconstruction. *AJR Am J Roentgenol*. 2006;186(6 Suppl 2):S391–4.
- La Grutta L, Runza G, Galia M, et al. Atherosclerotic pattern of coronary myocardial bridging assessed with CT coronary

- angiography. *Int J Cardiovasc Imaging*. 2011 Feb 24; [Epub ahead of print].
25. Hwang JH, Ko SM, Roh HG, et al. Myocardial bridging of the left anterior descending coronary artery: depiction rate and morphologic features by dual-source CT coronary angiography. *Korean J Radiol*. 2010;11:514–21.
 26. Koşar P, Ergun E, Öztürk C, et al. Anatomic variations and anomalies of the coronary arteries: 64-slice CT angiographic appearance. *Diagn Interv Radiol*. 2009;15:275–83.
 27. La Grutta L, Runza G, Galia M, et al. Prevalence of myocardial bridging and correlation with coronary atherosclerosis studies with 64-slice CT coronary angiography. *Radiol Med*. 2009;114:1024–36.
 28. Rodríguez-Granillo GA, Rosales MA, Pugliese F, et al. Prevalence and characteristics of major and minor coronary artery anomalies in an adult population assessed by computed tomography coronary angiography. *EuroIntervention*. 2009;4:641–7.
 29. Liu H, Huang MP, Liang CH, et al. Detection and its clinical value of myocardial bridging with 64-slice spiral CT coronary angiography. *Nan Fang Yi Ke Da Xue Xue Bao*. 2009;29:236–8.
 30. Atar E, Kornowski R, Fuchs S, et al. Evaluation of myocardial bridge with multidetector computed tomography. *J Cardiovasc Comput Tomogr*. 2007;1:78–83.
 31. Kim SY, Lee YS, Lee JB, et al. Evaluation of myocardial bridge with multidetector computed tomography. *Circ J*. 2010;74:137–41.
 32. Chen YD, Wu MH, Sheu MH, et al. Myocardial bridging in Taiwan: depiction by multidetector computed tomography coronary angiography. *J Formos Med Assoc*. 2009;108:469–74.
 33. 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;22:713–7.
 34. Ishii T, Asuwa N, Masuda S, et al. Atherosclerosis suppression in the left anterior descending coronary artery by the presence of a myocardial bridge: an ultrastructural study. *Mod Pathol*. 1991;4:424–31.
 35. Masuda T, Ishikawa Y, Akasaka Y, et al. The effect of myocardial bridging of the coronary artery on vasoactive agents and atherosclerosis localization. *J Pathol*. 2001;193:408–14.
 36. Ishikawa Y, Akasaka Y, Ito K, et al. Significance of anatomical properties of myocardial bridge on atherosclerosis evolution in the left anterior descending coronary artery. *Atherosclerosis*. 2006;186:380–9.
 37. Bourassa MG, Butnaru A, Lespérance J, et al. Symptomatic myocardial bridges: overview of ischemic mechanisms and current diagnostic and treatment strategies. *J Am Coll Cardiol*. 2003;41:351–9.
 38. Vallejo E, Morales M, Sánchez I, et al. Myocardial perfusion SPECT imaging in patients with myocardial bridging. *J Nucl Cardiol*. 2005;12:318–23.
 39. Xiang DC, Gong ZH, He JX, et al. Characteristics of stress tests and symptoms in patients with myocardial bridge and coronary artery spasm. *Coron Artery Dis*. 2009;20:27–31.
 40. Kunamneni PB, Rajdev S, Krishnan P, et al. Outcome of intracoronary stenting after failed maximal medical therapy in patients with symptomatic myocardial bridge. *Catheter Cardiovasc Interv*. 2008;71:185–90.
 41. Schifferdecker B, Benotti J. Myocardial infarction induced by myocardial bridging: report of successful percutaneous therapy and review of the literature. *J Invasive Cardiol*. 2005;17:E52–4.