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ORIGINAL RESEARCH

Relationship between incidentally detected calcification of the mitral valve on 64-row multidetector computed tomography and mitral valve disease on echocardiography

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Background: Mitral valve calcification is often incidentally detected on chest computed tomography (CT) scans obtained for a variety of noncardiac indications. In this study, we evaluated the association between mitral valve calcification incidentally detected on chest CT and the presence and severity of mitral valve disease on echocardiography.

Methods: Of 760 patients undergoing 64-row multidetector CT of the chest, 50 with mitral valve calcification and 100 controls were referred on for echocardiography. Calcifications of the mitral valve leaflet and annulus were assessed for length, Agatston score, and site, and were compared with echocardiographic findings.

Results: Mitral valve calcification was noted in 59 (7.7%) patients on multidetector CT. Fifty of these patients were assessed by echocardiography, and 32 (64%) were found to have mitral annular calcification. Nine patients (18%) had posterior mitral valve leaflet calcification, and both mitral valve leaflet and annular calcification were detected in nine (18%) cases. Nine (18%) patients had mild, three (6%) had moderate, and one (2%) had severe mitral stenosis. None of the patients with isolated mitral annular calcification had mitral stenosis; however, all the patients with mitral stenosis showed mitral valve leaflet calcification with or without mitral annular calcification ($P < 0.001$). Moreover, patients with mitral stenosis had a larger mitral calcification length and greater Agatston scores in comparison with those without mitral stenosis ($P = 0.001$). While 31 patients (62%) with mitral calcification had mitral regurgitation on echocardiography, 21 (21%) in the control group showed mitral regurgitation ($P = 0.001$).

Conclusion: Mitral valve leaflet calcification, with or without annular calcification, may be an indicator of mitral stenosis. Mitral calcification can also be considered as an indicator for mitral regurgitation in general. Therefore, patients with mitral valve calcification detected incidentally on chest CT scan may benefit from functional assessment of the valve using echocardiography.

Keywords: mitral annular calcification, mitral valve leaflet calcification, multidetector computed tomography, mitral regurgitation, mitral stenosis

Introduction

Mitral annular calcification, characterized by calcium and lipid deposition in the annular fibrosa of the mitral valve, is a degenerative process with multiple etiologies commonly occurring in the elderly.[1,2] Mitral valve calcifications may develop in rheumatic mitral stenosis or as a result of degenerative changes in elderly patients.[3] Mitral annular calcification may have several consequences, ie, patients with mitral annular calcification

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have a higher risk of left atrial or ventricular enlargement, atrial fibrillation, conduction defects, mitral regurgitation, mitral stenosis, hypertrophic cardiomyopathy, and bacterial endocarditis. Such patients also have a higher incidence of cardiovascular events, thromboembolic cerebrovascular events, permanent pacemaker implantation, and valve replacement.[4–6]

Computed tomography (CT) has been demonstrated to be superior to other imaging modalities for detecting mitral calcification.[7] Valvular calcification can be detected incidentally on chest CT scans obtained for a variety of noncardiac indications, and on CT angiography for assessment of coronary artery disease.[3] Several previous studies have suggested a correlation between aortic valve calcification detected incidentally on CT scans and the severity of aortic valve disease seen on echocardiography.[8–12] However, such a correlation between mitral valve calcification detected incidentally and the severity of mitral valve diseases on echocardiography has not been so widely investigated.[3] Therefore, the aim of the present study was to evaluate the association between mitral valve calcification detected incidentally on chest CT and the presence and severity of mitral valve disease seen in echocardiography.

Materials and methods

Patients

In a prospective study of 760 patients aged over 30 years who underwent multidetector CT of the chest for noncardiac indications, 50 (6.6%) were incidentally found to have mitral valve calcification. These patients were then referred to a cardiologist (MT) to perform echocardiography within a maximum of 2 months to evaluate mitral valve function and to screen for mitral valve stenosis or regurgitation. To decrease the effect of confounding variables such as age, a control group of 100 individuals (58 females and 42 males), with no evidence of mitral valve calcification on multidetector CT, was randomly selected. All controls selected were aged $>$ 60 years, given that all of the cases positive for mitral valve calcification were within this age group. Patients with a history of valvuloplasty, mitral valve replacement surgery, or rheumatic heart disease were excluded. The study was approved by the local ethics committee, and written informed consent was obtained from all participants prior to the study.

Multidetector CT

Multidetector CT examinations were performed using a 64-row multidetector CT scanner (Somatom Sensation 64; Siemens, Forchheim, Germany). Chest CT examinations were performed during inspiratory breath-hold not using contrast and without electrocardiographic gating. Scans were reconstructed with an effective section thickness of 0.6 mm and an increment of 0.4 mm. The field of view was individually adapted to the patient's body habitus. All multidetector CT scans were reviewed on an external workstation (Wizard Medical Solutions, Mount Waverley, Australia) by a radiologist with expertise in chest CT. Mitral valve calcifications were subjectively characterized by the following criteria: presence, location (annulus or leaflet), Agatston score, and length in millimeters.[13,14] For measuring the length of calcification, multiplanar reconstruction was used to obtain the longest diameter, and if calcification was extending from the annulus to the leaflet, we measured them together as one unit. We measured each case six times and finally selected the most common measurement obtained.

Echocardiography

A comprehensive echocardiographic study including M-mode, two-dimensional echocardiography, and Doppler echocardiographic measurements, was performed in all patients using an ultrasound system (Vivid 7; GE Healthcare, Horten, Norway) operated by an experienced cardiologist blinded to the multidetector CT findings.[15–18] The presence of mitral valve stenosis was defined as restriction of leaflet motion leading to a transmitral diastolic gradient. The severity of mitral stenosis was classified according to American College of Cardiology/American Heart Association guidelines.[19] A valve area $>$ 1.5 cm^2 and a mean transmitral gradient $<$ 5 mmHg was classified as mild stenosis; a valve area of 1.0–1.5 cm^2 and a mean transmitral gradient of 5–10 mmHg as moderate stenosis; and a valve area $<$ 1.0 cm^2 and a mean transmitral gradient $>$ 10 mmHg as severe mitral stenosis. The severity of mitral regurgitation was also classified as mild, moderate, or severe according to American College of Cardiology/American Heart Association guidelines.[19] Left atrial and ventricular size, valve leaflets, color flow jet area, mitral valve inflow wave pulse, jet density, jet contour, vena contracta width, and volume and percentage of regurgitation were factors included in the classification of mitral regurgitation severity.

Statistical analysis

Data are presented as the mean ± standard deviation or percentage. The statistical analysis was performed using SPSS for Windows version 16.0 (IBM Corporation, Armonk, NY) with Fisher's exact test, an independent-

samples *t*-test, and one-way analysis of variance, as appropriate. A *P*-value < 0.05 was considered to be statistically significant.

Results

Mitral valve calcification was noted in 59 (7.7%) of 760 patients on multidetector CT. All of the cases detected were aged > 60 years. Five patients refused to take part in the study and four died before echocardiography could be performed due to the severity of their underlying disease. Baseline characteristics of the patients and controls are shown in Table 1. There were no differences in sex, age, and a prevalence of hypertension, hyperlipidemia, and diabetes mellitus between the groups (Table 1). Of the remaining 50 patients with mitral valve calcification, 32 (64%) had mitral annular calcification, with 24 (48%) having calcification at the posterior annulus and eight (16%) at the anterior annulus. Nine patients (18%) had calcification of the posterior mitral valve leaflet and both mitral valve leaflet and annular calcification were detected in nine (18%) cases.

While none of the controls had mitral stenosis on echocardiography, nine (18%) patients in the mitral valve calcification group had mild, three (6%) had moderate, and one (2%) had severe mitral stenosis ($P = 0.001$). The latter case was a 78-year-old woman with mitral annular calcification at the posterior and anterior annuli, anterior mitral valve leaflet calcification measuring 60 mm in length, and an Agatston score of 5582. Three patients with moderate mitral stenosis had both posterior mitral annular and valve leaflet calcification measuring 36, 35, and 30 mm in length, with Agatston scores of 5235, 4307, and 3560, respectively. Four patients with mild mitral stenosis had posterior mitral valve leaflet calcification, whereas five patients had both posterior mitral valve leaflet and annular calcification, with a lower calcification size and Agatston score in comparison with patients having moderate mitral stenosis. Additionally, in five patients without echocardiographic signs of mitral stenosis, multidetector CT revealed minor calcifications of the mitral valve leaflet (length < 7 mm and Agatston score < 76).

None of the patients with isolated mitral annular calcification had mitral stenosis; however, all patients with mitral stenosis showed mitral valve leaflet calcification with or without mitral annular calcification ($P < 0.001$). Mitral stenosis was not detected on echocardiography in only two of 15 patients (13%) with mitral valve leaflet calcification. Moreover, patients with mitral stenosis had a greater mitral calcification length and higher Agatston scores than those without mitral stenosis (independent-samples *t*-test, $P = 0.001$). However, calcification length and Agatston score was not significantly different between patients with mild, moderate, and severe mitral stenosis ($P = 0.32$ and $P = 0.09$, respectively; Table 2).

Thirty-one patients (62%) with mitral calcification had mitral regurgitation on echocardiography and 21 individuals in the control group (21%) showed mitral regurgitation ($P = 0.001$; Table 1). The severity of mitral regurgitation was mild in both study groups. No significant association was found between site and length of calcification and the presence and severity of mitral regurgitation ($P > 0.05$).

Discussion

The present study suggests that mitral valve leaflet calcification, with or without mitral annular calcification, may be an indicator for mitral stenosis. Moreover, mitral calcification

Table 1 Baseline characteristics of the study groups

Parameters	Mitral calcification (n = 50)	Control group (n = 100)	*P*-value
Age (years)	69.5 ± 8.64	69.46 ± 8.55	0.97
Sex (female:male)	29:21	58:42	0.85
Hypertension, n (%)	17 (34%)	32 (32%)	0.47
Hyperlipidemia, n (%)	21 (42%)	32 (32%)	0.15
Diabetes mellitus, n (%)	15 (30%)	25 (25%)	0.32
Distribution of mitral calcification on MDCT, n (%)			
Posterior annulus	24 (48%)	0	N/A
Anterior annulus	8 (16%)	0	N/A
Posterior leaflet	9 (18%)	0	N/A
Posterior annulus and leaflet	6 (12%)	0	N/A
Whole annulus and posterior leaflet with/without anterior annulus	3 (6%)	0	N/A
Mitral stenosis on echocardiography, n (%)	13 (26%)	0	0.001
Mitral regurgitation on echocardiography, n (%)	31 (62%)	21 (21%)	0.001

Abbreviation: MDCT, multidetector computed tomography; N/A, not applicable.

Table 2 Length of mitral calcification and Agatston scores for different degrees of mitral valve stenosis

	Calcification length (mm)	Agatston score
Whole population	13.34 ± 11.08	863.3 ± 627.7
No MS	8.83 ± 4.6	125.9 ± 276.9
Mild MS	19.68 ± 8.78	1856.2 ± 1534.9
Moderate MS	40.25 ± 13.52	4671 ± 915.5
Severe MS	60.00 ± 0.0	5585

Abbreviation: MS, mitral stenosis.

can be considered as an indicator of mitral regurgitation in general. Two earlier retrospective studies of incidental findings on electron beam CT and 4-multidetector and 16-multidetector CT by Hunold et al[20] and Mahnken et al[3] found mitral valve calcification in about 7%–8% of patients, which is similar to our findings.

Like the previous reports by Mahnken et al[3] and Willmann et al,[21] the present study differentiated mitral valve leaflet calcification from mitral valve annular calcification using multidetector CT. In a study evaluating mitral annular calcification and mitral valve dysfunction only by echocardiography, Movahed et al[22] demonstrated that mitral annular calcification was significantly associated with isolated mitral regurgitation but not with mitral stenosis. In the current study, mitral calcification was significantly associated with both mitral stenosis and mitral regurgitation. The former finding is compatible with that of the study by Mahnken et al[3] in which a significant correlation between mitral stenosis and mitral calcification was described. However, mitral regurgitation was not assessed in their study.

Most of the previous studies were based on subjective criteria for the degree of calcification with regard to its extension. In contrast, Movahed et al studied their cases based on calcification thickness at echocardiography.[22] The present study measured the metric length of the calcification as a quantitative criterion of calcification and found a significant association with the presence of mitral stenosis. Mahnken et al[3] showed a significant relationship between the degree of mitral valve calcification on multidetector CT and the severity of mitral valve disease as determined by echocardiography. However, their study lacked any differentiation between rheumatic and degenerative mitral valve disease.[3]

Further, Mahnken et al[3] reported the importance of the site of calcification, as the presence of mitral valve leaflet calcification indicated the presence of mitral sclerosis or stenosis. Although the correlation between presence of mitral valve sclerosis or stenosis was worse for mitral annular calcification, they suggested a good agreement between mitral annular calcification and mitral valve stenosis, but the discriminative power of mitral annular calcification on multidetector CT was insufficient for clinical purposes (missing differentiation between the etiologies of mitral valve disease). In the current study, all patients with mitral stenosis had mitral valve leaflet calcification, with or without mitral annular calcification, but no mitral stenosis was detected in patients with isolated mitral annular calcification. Therefore, the site of calcification is an important factor in mitral stenosis, but not on multidetector CT. The latter was due to insignificant association between multidetector CT and the site of calcification in our study.

The present study has some limitations. Because there were few cases with mitral stenosis, we could not determine a cutoff length for detecting mitral stenosis. Therefore, further studies with a larger sample size seem necessary. On the other hand, chest CT for a noncardiac indication is generally performed without electrocardiographic gating, and motion artifact may negatively influence measurement of the exact length of calcification.

In conclusion, our data suggest that mitral valve leaflet calcification, with or without mitral annular calcification, may be an indicator of mitral stenosis. Moreover, mitral calcification can be considered as an indicator on multidetector CT in general. Therefore, patients with incidentally detected mitral valve calcification on chest CT scan may benefit from a valvular functional assessment using echocardiography.

Disclosure

The authors report no conflicts of interest in this work.

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