

Incidence and Characteristics of Valve Calcification on Computed Tomography Angiography

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Abstract

Background: Heart valve diseases are common and associated with significant morbidity and mortality, often sharing risk factors with coronary artery disease. Coronary computed tomography angiography (CCTA) is increasingly used to detect incidental valvular calcifications, aiding in diagnosis, risk assessment, and management.

Objective: To evaluate the CCTA for incidence of mitral and aortic valvular calcification and their association with cardiovascular prognosis, predictors, and coronary artery disease.

Methods: This retrospective study was conducted at the Institute of Cardiology, Chaudhary Pervaiz Elahi Institute of Cardiology, Multan from April 2023 to April 2024. All the patients suspected of angina due to coronary artery disease who underwent the CCTA were included. The CCTA scans of all 534 patients were reviewed to identify the presence of mitral or aortic valve calcification. The primary composite outcomes were mortality by cardiac event, non-fatal myocardial infarction, or stroke.

Results: The mean age of patients remained to be 63±6 years. On evaluation of 534 CCTA scans, 75 patients (14%) had aortic valvular calcification and 21 patients (4%) had mitral calcification. Coronary artery calcification was a significant predictor of the composite outcome in patients with both aortic ($p=0.025$) and mitral valve calcification ($p=0.010$) on multivariate analysis; however, the presence of valvular calcification alone in either group was not independently associated with the primary composite outcome.

Conclusion: Valve calcification is common in CCTA and has an association with coronary artery disease; driven by presence and severity of coronary artery disease but not directly by calcification.

Key words: Angiography, calcification, computed tomography, coronary artery disease.

Introduction

Heart valve diseases are frequent conditions with high rates of mortality and morbidity and have similar predictors as coronary heart disease.¹ Computed tomography (CT) of patients with valvular calcification may be useful in identifying

undiagnosed valvular heart disease. Coronary computed tomography angiography (CCTA) is the recommended investigation tool to diagnose coronary artery diseases non-invasively.² CCTA is helpful in risk stratification and screening as it can identify incidental valvular calcification.³ Aortic calcification is indicative of aortic stenosis and calcium score on computed tomography and is associated with stenosis severity on echocardiography.⁴

According to international guidelines sex-specific aortic valve CT calcium score is a validated and recommended tool for evaluation of severity of aortic stenosis when echocardiography is discordant.⁵ Mitral valve annular calcification on CCTA is indicative of mitral valve dysfunction. Studies suggest that patients with mitral valve calcification and aortic stenosis are at increased risk of cardiac events and cardiovascular mortality,

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Authors Contribution

NP conceptualized the project. HAS & FW did the data collection. US did the literature search. HAS & ZUI performed the statistical analysis. Drafting, revision & writing of manuscript were done by AF.

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though the underlying causes of these associations are unclear.⁶

The growing utility of CCTA in providing insights about the incidence and characteristics of valvular calcification and its implications for risk estimation of cardiovascular events. It is necessary to understand the frequency of these calcifications in patients undergoing CCTA for the probable occurrence of coronary artery disease and its association with pre-existing cardiovascular risk factors. Therefore this study aimed to the CCTA for incidence of mitral and aortic valvular calcification and their association with cardiovascular prognosis, predictors, and coronary artery disease.

Methods

This retrospective study was conducted in the Institute of Cardiology, Chaudhary Pervaiz Elahi Institute of Cardiology, Multan from April 2023 to April 2024. All the patients suspected of angina due to coronary artery disease who underwent CT via 320 multidetector were included. Patients with pre-existing diagnosis of severe valvular disease, history of valve surgery and those contraindicated to CCTA were excluded. The CCTA scans of all 534 patients enrolled during the study period were reviewed to identify the presence of mitral or aortic valve calcification.

The data of CCTA-enhanced and non-contrast electrocardiography computed tomography was used for calcium scoring through a pre-existing technique considered by Williams et al.⁷ Aortic and mitral valve calcification were quantitatively assessed using the Agatston scoring method⁸ on CCTA images evaluated for the diagnosis of valve calcification. Semi-automatic software was used to assess non-contrast images. Information on clinical outcomes was obtained from medical records. Valvular surgery was identified using surgical coding information.

SPSS version 23.0 was used for data analysis. The primary composite outcomes were mortality by cardiac event, non-fatal MI, or stroke. Mean±SD was used to present quantitative data while qualitative data was presented as frequency and percentages. The association between aortic and mitral calcification and predictors of cardiovascular predictors was assessed using ordinal regression analysis. The multivariable analysis included valvular calcification, the incidence of obstructive CAD, and coronary artery

calcification. p value <0.05 was considered statistically significant.

Results

Of 534 CT images, targeted cohort of 96 (18%) showed valvular calcification among which 75 patients (14%) had aortic valvular calcification and 21 patients (4%) had mitral calcification. A total 56 (74.7%) patients in aortic valve calcification group and 14 (66.6%) patients in mitral valve calcification group were males. Incidence of diabetes (23.8% vs 20%), hypertension (57% vs 52%) and history of CHD (19% vs 16%) was slightly higher in mitral valve calcification group than aortic valve calcification group as presented in Table-1. Only 19 patients out of total 96 (20%) approached composite outcome; 2 patients died of cardiovascular events, 14 patients had non-fatal myocardial infarction and 3 patients suffered from non-fatal stroke. Coronary artery calcium score was higher in patients with mitral calcification (412, IQR 37-1057) Agatston Units (AU) than in patients without it (19, IQR 1-201) AU ($p <0.001$). Calcium scores in the coronary artery and mitral valve were not correlated ($r =0.04$, $p =0.67$).

Coronary artery calcification was a significant predictor of composite outcome in patients with aortic valve calcification ($p =0.025$) (Table-2). Coronary artery calcification remained a significant predictor in the multivariate analysis of patients with mitral valve calcification ($p =0.010$). However, the incidence of calcification in both groups was not independently associated with the primary composite outcome (Table-3).

Discussion

This retrospective study was conducted to evaluate the incidence and clinical characteristics of valvular calcification which revealed 20% prevalence i.e. every 1 in 6 patients. Valve calcifications are related to cardiovascular predictors and CAD. Patients with valve calcifications had a threefold increased risk of experiencing a cardiac event, however, this increased risk was strongly associated with the presence and severity of CAD. This implies that the poor outcome observed in patients with valvular calcification is more accurately attributed to the co-occurrence of CAD, rather than a direct consequence of calcification itself.

Table 1: Characteristics and history of study subjects.

Characteristics	Aortic valve calcification (n=75)	Mitral valve calcification (n=21)
Age	63 ± 6	64 ± 6
Male gender	56 (74.7%)	14 (66.6%)
BMI	29 ± 4	29 ± 4
Atrial fibrillation	3 (4%)	1 (5%)
Current smokers	12 (16%)	2 (9.5%)
Ex-smokers	32 (42.7%)	11 (52.3%)
Non-smokers	31 (41.3%)	8 (38%)
Hypertension	39 (52%)	12 (57%)
Diabetes	15 (20%)	5 (23.8%)
Family history of CHD	29 (38.7%)	7 (33.3%)
History of CHD	12 (16%)	4 (19%)
History of PAD	3 (4%)	1 (5%)
History of CVD	9 (12%)	2 (10%)
Total cholesterol	180 ± 73	181 ± 83
Angina Symptoms	Typical Atypical Non-I	11 (52%) 4 (19%) 6 (28.5%)
Risk score	25 ± 10.4	24.4 ± 10.6

*CHD: Coronary heart disease, CVD: Cardiovascular disease, PAD: Peripheral artery disease

Table 2: Regression analysis for predictors of the primary composite outcome in patients with aortic valve calcification.

	Univariate analysis	p value	Multivariate analysis	p value
Aortic valve calcification	2.90 (1.58-5.20)	<0.001	1.78 (0.99-3.34)	0.078
Coronary artery calcification	1.20 (1.08-1.30)	<0.001	1.07 (1.06-1.25)	0.025
Obstructive CAD	2.89 (1.68-5.08)	<0.001	1.47 (0.80-3.02)	0.236

Table 3: Regression analysis for predictors of the primary composite outcome in patients with mitral valve calcification.

	Univariate analysis	p value	Multivariate analysis	p value
Mitral valve calcification	3.50 (1.46-8.10)	0.006	2.19 (0.87-5.32)	0.081
Coronary artery calcification	1.21 (1.08-1.31)	<0.001	1.10 (1.06-1.28)	0.010
Obstructive CAD	2.89 (1.66-5.11)	<0.001	1.48 (0.82-3.08)	0.220

In the present study, calcification patients were three times more likely to suffer mortality due to cardiac events, myocardial infarction, and stroke which was also dependent upon coronary artery calcium score that indicates CAD prognosis. Similar findings were shown in a study conducted in lung cancer subjects where aortic calcification was not sufficient to predict the prognosis of coronary calcification.⁹ However, these results differ from other studies in which a relationship between poor cardiac outcomes and aortic stenosis or valve calcification.¹⁰⁻¹² The meta-analysis by De Minno et al reported that aortic calcification was significantly related to increased mortality and morbidity risk of cardiovascular events. This difference can be due to distinct study populations between both studies.

In a study conducted in elderly patients, aortic stenosis increased the risk of mortality by cardiac event and myocardial infarction by 50%.¹³ In a MESA study, aortic calcification increased the risk of MI by more than 70% and the risk of cardiac

events by 50%.¹⁴ As indicated in our study, this association was not significant after adjusting predictors of cardiac disease, inflammation biomarkers, and coronary calcium score. However, this study was a population-based cohort study, while present study had patients with suspected angina. Additionally, the definition of poor cardiac outcome was aortic stenosis in this study, a condition not set in our study.

Our study provides evidence that valvular calcification does not have a direct causal relationship with increased risk of cardiovascular events and this association is dependent on CAD. The results revealed a strong association between atherosclerosis and predictors of cardiovascular disease with valvular calcification. In coherence with previous research, aortic valve calcification was independently associated with age, diabetes, male gender, hypertension, and history of cerebrovascular diseases where age was also a risk factor for mitral valve calcification, indicating

overlapped mechanisms driving these pathologies.^{15,16} Both Han et al and Erlandsson et al concluded that age and presence of atherosclerosis combined serve as risk factors for aortic valve and arterial calcification. However, several factors including oxidative stress, inflammation and genetics are linked to this association, which is why our results are different from these mechanistic studies.

The patients with valvular calcification in our study had a co-occurring coronary calcification indicated by calcium score showing the co-existence of valve calcification and its risk factors and atherosclerosis. However, the association between aortic calcium score and coronary calcification was weak and no association was found with mitral calcification.^{17,18} Valvular heart disease may indicate coronary calcification but CAD does not predict valvular calcification visible on echo.

Our study has some limitations. We assessed limited clinical events and we did not manage patients based on imaging. As 2/3rd the population did not have angina as a result of CAD our findings may not be applied to the general population or asymptomatic. The progression of calcification was not recorded in our study and only an association between severity of calcification and cardiovascular predictors was recorded.

Conclusion

Valve calcification is common in computed tomography angiography and has an association with coronary artery disease. The increased risk of cardiovascular events is driven by presence and severity coronary artery disease and not directly by calcification.

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Availability of Data: The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethical Approval: The Ethics Review Committee of Chaudhary Pervaiz Elahi Institute of Cardiology, Multan approved the study via letter no. L.No.R/12/148.

Conflict of Interest: None declared.

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