Section: Cardio-Thoracic Surgery

Original Research Article

RETROGRADE ANALYSIS OF PREDICTABILITY OF CORONARY CALCIUM SCORE IN ESTABLISHED CORONARY ARTERY DISEASE PATIENTS UNDERGOING CORONARYARTERY BYPASS GRAFTING

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ABSTRACT

Background: Coronary artery disease (CAD) remains a leading cause of morbidity and mortality worldwide. Early identification of significant coronary artery involvement is crucial for timely intervention. Coronary artery calcium (CAC) scoring using computed tomography has emerged as a non-invasive tool for assessing atherosclerotic burden and predicting CAD severity. **Objectives:** The primary objective of this study was to determine the predictability of significant coronary artery disease using coronary calcium scoring (Agatston score). The secondary objectives were to correlate calcium scores with the degree of coronary vessel occlusion and with associated cardiovascular risk factors.

Materials and Methods: This observational study included 72 patients diagnosed with triple vessel coronary artery disease who underwent coronary artery bypass grafting (CABG) over a period of six months at our center. All patients were evaluated using conventional coronary angiography and CT coronary angiography for calcium scoring. Demographic data, risk factors, and angiographic findings were recorded and analyzed.

Results: Among the study population, 52 (72.2%) were males and 20 (27.8%) were females, with a mean age of 57 years. Diabetes mellitus was present in 61% of patients, hypertension in 68%, and a positive family history of CAD in 64%. A history of smoking and alcohol consumption was noted in 66% and 61% of patients, respectively. Significant left main coronary artery disease (>50% stenosis) was observed in 7% of patients. Approximately 10% of patients had complete occlusion of the left anterior descending artery, while 80–90% stenosis was seen in nearly 65% of patients. Only 7% of patients had low Agatston scores, whereas the majority demonstrated moderate to high scores, indicating a strong association between elevated coronary calcium scores and the severity of coronary artery disease.

Conclusion: Coronary calcium scoring is a valuable non-invasive tool for predicting the presence and severity of significant coronary artery disease. Higher Agatston scores correlate well with the degree of vessel occlusion and the presence of conventional cardiovascular risk factors, making it a useful adjunct in risk stratification and clinical decision-making in patients with suspected or established CAD.

Keywords: Coronary artery disease, Coronary calcium score, Agatston score, CT coronary angiography, Triple vessel disease, Coronary angiography, Coronary artery bypass grafting (CABG) and Atherosclerosis.

INTRODUCTION

A coronary artery calcium score (CACS) examination is a non-invasive examination of the coronary arteries in which the amount of calcium in the coronary arteries is determined using cardiac computed tomography.[1,2] Agatston et al. developed this method of calculation and the Agatston score is currently the standard for measurements during a semi-automatic analysis.[1,3,4] With the exception of patients with renal failure, who may also have medial calcification, coronary calcium is exclusively the result of coronary atherosclerosis.

The amount of calcium in the arteries roughly correlates with extent of any atherosclerotic plaque that is present in the coronary arteries.[5] The coronary artery calcium score, which is calculated in cardiac computed tomography, can support a cardiovascular risk evaluation, and therefore, it can support clinical decisions. Interestingly, Japanese researchers confirmed that an elevated CACS that is determined using coronary computed tomography angiography is an independent predictor of mid- to long-term cardiovascular mortality and morbidity in patients that are suspected of having coronary artery disease (CAD).[6]

MATERIALS AND METHODS

Study Design and Setting: This retrospective observational study was conducted in the Department of Cardiothoracic Surgery at Nizam's Institute of Medical Sciences (NIMS), Hyderabad, after obtaining approval from the Institutional Ethics Committee.

Study Duration: The study was carried out over a period of one year from 2023 to 2024.

Sample Size: A total of 72 patients were included in the study.

Study Population: Patients diagnosed with triple vessel coronary artery disease who underwent coronary artery bypass grafting (CABG) at NIMS were included.

Inclusion Criteria: Patients aged ≥ 40 years of either gender, who underwent CABG in NIMS hospital during the period of study.

Exclusion Criteria: Patients with acute coronary syndrome, who underwent for emergency surgery, Patients undergoing Redo surgery, Patients with Renal failure and Patients with abnormal cardiac rhythm -using this format for materials and methods

Data Collection: Patient demographic details, clinical history, and risk factors were obtained from hospital records and discharge summaries. Conventional coronary angiography reports and CT coronary angiography findings were reviewed. Coronary artery calcium scoring (CACS) was calculated from CT coronary angiography using the Agatston method and expressed in Agatston Units (AU).

Grouping of Patients: Based on coronary artery calcium score, patients were categorized into three groups:

Group 1 (G1): CACS = 0 AU

Group 2 (G2): CACS = 1–399 AU

Group 3 (G3): CACS ≥ 400 AU

Data Recording: All collected data were tabulated and verified for accuracy and consistency. Continuous variables were expressed as mean ± standard deviation (SD), while categorical variables were presented as percentages.

Statistical Analysis: Statistical analysis was performed using appropriate statistical methods. The association between coronary calcium score and severity of coronary artery disease, as well as with cardiovascular risk factors, was analyzed. Results were interpreted using descriptive and inferential statistics where applicable.

RESULTS

The present study included a total of 82 patients, with a marked male predominance (86.1%) compared to females (13.9%), yielding a male-to-female ratio of approximately 3:1. The study population consisted of patients above 40 years of age, with the majority falling within the 55–65 years age group and a mean age of 57 years. The average body mass index (BMI) was 26.5 kg/m², with most patients having BMI values between 21 and 27.

Table 1: Clinical Risk Factors

Risk Factor	Present (n, %)	Absent (n, %)
Diabetes Mellitus	43 (61.1%)	29 (38.9%)
Hypertension	48 (68.1%)	24 (31.9%)
Family History of CAD	44 (63.9%)	28 (36.1%)
Smoking	47 (66.7%)	25 (33.3%)
Alcohol Consumption	43 (61.1%)	29 (38.9%)

A high prevalence of cardiovascular risk factors was observed. Hypertension was the most common risk factor, present in 68.1% of patients, followed by diabetes mellitus in 61.1%. A positive family history of coronary artery disease (CAD) was noted in 63.9% of patients. Additionally, 66.7% of patients had a history of smoking, while 61.1% reported alcohol consumption.

Table 2: Coronary Artery Involvement

Artery	Degree of Stenosis	No. of Patients	Percentage
LAD	100%	7	9.7%
	90%	29	38.9%
	80%	18	25%
	70%	17	23.6%
	50%	1	1.4%
LCX	100%	1	1.4%
	90%	21	29.2%
	80%	23	31.9%
	70%	14	20.8%
	60%	8	11.1%
	50%	3	4.2%
RCA	100%	15	19.1%
	90%	32	44.1%
	80%	16	22.1%
	70%	8	11.8%
	50%	1	1.5%

Coronary angiographic findings revealed significant multi-vessel disease. In the left anterior descending (LAD) artery, the most common degree of stenosis was 90% (38.9%), followed by 80% (25%). Similarly, in the left circumflex (LCX) artery, 80% stenosis was most frequently observed (31.9%). The right coronary artery (RCA) showed the highest proportion of severe stenosis, with 90% involvement in 44.1% of patients. Critical left main coronary artery (LMCA) disease (>50% stenosis) was present in a small subset of patients.

Table 3: Coronary Calcium Score (Agatston Score)

Score Range	No. of Patients	Percentage
11–100	5	6.9%
101–400	31	43.3%
>400	36	50%

Coronary artery calcium scoring demonstrated a high burden of atherosclerosis, with 50% of patients having an Agatston score greater than 400, while 43.3% had scores between 101 and 400. Only a small proportion (6.9%) had scores between 11 and 100.

Table 4: Surgical Profile (Number of Grafts & LMCA Involvement)

Parameter	Category	No. of Patients	Percentage
Number of Grafts	5 grafts	3	4.2%
	4 grafts	38	51.5%
	3 grafts	29	41.3%
	2 grafts	2	2.8%

Surgical data indicated that the majority of patients underwent multiple graft procedures, with 4 grafts being the most common (51.5%), followed by 3 grafts (41.3%). A small percentage underwent either 2 or 5 graft procedures.

DISCUSSION

A coronary artery calcium score (CACS) examination is a non-invasive examination of the coronary arteries in which the amount of calcium in the coronary arteries is determined using cardiac computed tomography. Coronary CT angiography is performed as a semi-invasive imaging modality for assessment of presence or absence of coronary artery disease. Invasive coronary angiography is still the gold standard investigation for both imaging of emergency and elective coronary artery intervention. Agatston et al,[7] developed this method of calculation and the Agatston score is currently the standard for measurements during a semi-automatic analysis. With the exception of patients with renal failure, who may also have medial calcification, coronary calcium is exclusively the result of coronary atherosclerosis. The amount of calcium in the arteries roughly correlates with extent of any atherosclerotic plaque that is present in the coronary arteries

According to the European Guidelines on cardiovascular disease prevention in clinical practice, the CACS can be considered for cardiovascular risk assessment in asymptomatic adults who are at a moderate risk.[8] The coronary artery calcium score, which is calculated in cardiac computed tomography, can support a cardiovascular risk evaluation, and therefore, it can support clinical decisions. Interestingly, Japanese researchers confirmed that an elevated CACS that is determined using coronary computed tomography angiography is an independent predictor of mid- to long-term cardiovascular mortality and morbidity in patients that are suspected of having coronary artery disease.[9] In this study we have compared the Coronary calcium scores of 72 patients who were diagnosed with conventional angiography proven

triple vessel disease and had undergone coronary artery bypass surgery procedure at our hospital.

In this study total number of cases were 72 with male predominance of 52 patients and female patients were 20. Tahira Nishtar et al,[10] study was conducted on 85 patients. Out of the 85 patients, 65 (76%) were male patients and 20 (23%) were female. Overall incidence of coronary artery disease had been more common among male gender over the past decades which attributes to many factors like unhealthy lifestyle, diet, co-morbid conditions like diabetes and hypertension and other factors.

In our study patients above age of 40 years were included, among them most of the patients were between age group 55 to 65 years. Average age group of patients in our study was 57 years. Early diagnosis of coronary artery disease is an important factor in reducing in the morbidity and disease burden. Coronary calcium score being comparable with conventional angiography can be used as a preliminary and a reliable diagnostic tool in early diagnosis of asymptomatic coronary artery disease in young patients also who are otherwise reluctant to undergo conventional angiography. With the annual increase in global burden of coronary artery disease prompt and early diagnosis of asymptomatic coronary artery disease will help in grater morbidity and morbidity from cardiac illness in the society.

Average BMI of the patients included in our study was 26.5, considering obesity to be an important contributing factor of cardiac diseases, most of the patients had BMI in the range of 21 to 27. Even though high BMI is considered as risk factor. Obesity-related insulin resistance, vascular endothelium dysfunction, increased sympathetic nervous system/renin-angiotensin-aldosterone system activity, and glomerulopathy lead to type 2 diabetes, coronary atherosclerosis, and chronic disease kidney disease that besides hypertension and dyslipidemia increase cardiovascular disease risk. Obesity increases cardiovascular disease risk through multiple pathways. Optimal reduction of cardiovascular disease risk in patients with obesity is likely to require therapy targeted at both obesity and obesity-associated conditions. Although many previous meta-analyses of epidemiological studies have demonstrated a relationship between body mass index (BMI) and mortality, inconsistent findings among cardiovascular disease patients have been observed. The coronary artery disease burden attributable to high BMI remains a challenging global health concern.[11]

Type 2 diabetes mellitus (T2DM) is a major risk factor of coronary artery diseases (CAD). In addition, 75% of T2DM patients die as a consequence of cardiovascular diseases, including CAD. In patients with T2DM, CAD is more likely to be a complex disease characterized by small, diffuse, calcified, multivessel disease (MVD) [12]. 61% (43) of our patients had history of T2DM and were under treatment for varying periods of time before admission.

Among the risk factors for CAD, high blood pressure (BP) is associated with the strongest evidence for causation and it has a high prevalence of exposure. Biologically normal levels of BP are considerably lower than what has typically been characterized as normal in research and clinical practice.[13] Cardiovascular disease in humans is primarily caused by a right-sided shift in the distribution of BP. In our study population 68% (48) patients were hypertensive at the time of presentation and were under prior treatment. Prevention of the age-related increase in BP would substantially reduce the vascular consequences usually attributed to aging. Even partial improvement in the age-related increase in BP would eliminate a large proportion of the existing burden of BP-related CAD.

The association between smoking and atherosclerotic cardiovascular disease was independent of traditional cardiovascular risk factors. A number of studies during the last several decades have identified detrimental effects of smoking on traditional cardiovascular risk factors, including blood pressure, lipids, and diabetes. Smoking tobacco is consistently among the leading risk factors for CAD; however, the relative contribution of smoking to the individual CAD outcomes remains less well studied, Despite the clear observational links between smoking and atherosclerosis, whether the effect of smoking on CAD is primarily mediated through correlated alterations of traditional cardiovascular risk factors, or operates via independent mechanisms is less clear.[14] Because the detrimental effects of smoking may persist for decades, clarifying the basis of the smoking-atherosclerosis relationship could enable more targeted risk-reduction strategies among both current and former smokers and identify novel treatment strategies for those at highest risk of CAD.

Left main coronary artery disease (CAD) is observed in 4% to 6% of patients undergoing coronary angiography. The prognosis for left main CAD is notably poor. Unprotected left main CAD presents the most unfavorable prognosis when compared to single-, double-, or triple-vessel disease, likely due to its frequent association with severe multivessel disease and a substantial amount of compromised myocardium. In our study cohort, 7% (5 patients) exhibited significant left main coronary artery disease, while approximately 70% of the participants had normal left main coronary artery conditions.

Furthermore, 10% of patients demonstrated complete occlusion of the left anterior descending artery, and lesions with 80% to 90% stenosis were present in about 65% of the patients, indicating a significant level of obstruction. Additionally, 19% (15 patients) had total involvement of the right coronary artery. Regarding the Agatston score, only 7% of patients scored between 11 and 100, while 43% had scores ranging from 101 to 400, indicating a moderate degree of plaque or obstruction. Notably, 50% (36 patients) had Agatston scores exceeding 400, which suggests the presence of diffuse atherosclerotic plaque. Despite only 7% of patients having lower

Agatston scores, the majority exhibited significant scores, highlighting a direct correlation between the extent of disease involvement and elevated coronary calcium scores in patients with triple vessel disease. The CACS offers critical prognostic insights that complement clinical scores derived from traditional risk factors and other diagnostic tests, such as C-reactive protein levels. Furthermore, CACS has the potential to influence and enhance the clinical management of patients. Therefore, conducting CACS is recommended for the comprehensive cardiovascular risk assessment of asymptomatic individuals classified as at intermediate risk according to the Framingham risk score. Conversely, coronary computed tomography angiography (CCTA) provides an in-depth evaluation of the coronary artery anatomy, enabling visualization of both the lumen and the arterial walls. In comparison to traditional invasive coronary angiography, CCTA demonstrates exceptional accuracy in identifying and primarily excluding significant obstructive lesions, while also offering additional prognostic information beyond traditional risk factors.[15]

CONCLUSION

The coronary artery calcium score (CACS) may serve as a valuable instrument for determining the most appropriate therapeutic strategy for coronary artery disease. Current clinical guidelines advocate for surgical revascularization in cases of left main coronary artery disease (LMCAD). Multi slice computed tomography (MSCT) demonstrates significant potential in identifying coronary stenosis and is particularly effective in ruling out coronary artery disease (CAD) due to its high negative predictive value. It provides precise visualization of coronary anomalies and its diagnostic accuracy is on par with that of invasive coronary angiography, establishing the foundation for coronary computed tomography angiography (CTA) as the preferred initial assessment. While invasive angiography exhibits greater sensitivity than CT angiography, both modalities share equivalent specificity in detecting stenotic lesions within the distal segments of the four primary coronary arteries.

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