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Risk Factor Associated Coronary Artery Calcium Score in Diabetes Patients

Abstract

Background. Diabetes mellitus (DM) is associated with an increased risk of coronary artery disease (CAD) and vascular calcification, although the mechanism of action remains complex. Coronary artery calcium (CAC) scoring is non-invasive method to assess subclinical atherosclerosis in this high-risk population.

Aim. To analyze the association between cardiovascular risk factors and CAC scores among diabetic patients.

Materials and Methods. This cross-sectional study included 52 diabetic patients recruited from the Cardiology Clinic of Wahidin Sudirohusodo General Hospital, Indonesia. Data on demographic characteristics, body mass index (BMI), blood pressure, dyslipidemia, family history of CAD, and HbA1c levels were collected. CAC scoring was performed using non-contrast ECG-gated CT, and results were categorized using the Agatston method. Statistical analyses included Spearman correlation, Mann–Whitney U test, and multivariate regression tests.

Results. The majority of patients were male (65.4 %) and under 60 years (82.7 %). High CAC scores (>400) were observed in 61.5 % of patients. A significant positive correlation was observed between HbA1c and total CAC score ($r = 0.317$; $p = 0.022$). In multivariate analysis, HbA1c remained an independent predictor of elevated CAC scores ($p < 0.05$), while hypertension was also significant in partial models. Other factors, including BMI, dyslipidemia, age, and family history of CAD, were not significantly associated with CAC scores.

Conclusions. Coronary artery calcification is highly prevalent among diabetic patients, including younger and non-obese individuals. HbA1c and hypertension were key predictors of CAC burden. These findings underscore the need for optimal glycaemic and blood pressure control, along with consideration of CAC screening for early cardiovascular risk stratification in diabetic populations.

Keywords: *Diabetes Mellitus, Coronary Artery Disease, Calcium Score, Hypertension, HbA1c.*

Introduction. Diabetes mellitus (DM) is a chronic metabolic disorder characterized by persistent hyperglycemia due to impairments in insulin secretion, insulin action, or both [1]. Hemoglobin A1c (HbA1c) is a key biomarker for assessing long-term glycemic control and is widely used for the diagnosis and management of diabetes [2]. Among the most serious complications of DM is atherosclerosis, which involves the buildup of plaques within the arterial walls and significantly increases the risk of Coronary Artery Disease (CAD) [3].

The standard diagnostic tool for detecting atherosclerosis is angiography, which provides direct visualization of arterial narrowing or obstruction [4]. In addition, non-invasive imaging methods such as Coronary Artery Calcium (CAC) scoring using computed tomography (CT) have become valuable in evaluating CAD risk. CAC scoring quantifies calcified plaque in the coronary arteries, offering an estimate of subclinical atherosclerosis severity [5]. Several studies have demonstrated a strong link between elevated HbA1c levels and increased CAD risk, as poor glycemic control contributes to vascular damage through inflammatory processes, oxidative stress, and endothelial dysfunction [6,7].

Furthermore, risk factors such as age, gender, body mass index (BMI), hypertension, smoking, dyslipidemia, family history of heart disease, and kidney dysfunction are also known to interact and amplify the risk of CAD in individuals with diabetes [8]. While CAC scoring provides an effective method for assessing calcified plaque burden, it does not directly visualize arterial narrowing.

In contrast, CT angiography (CTA) offers detailed three-dimensional imaging of coronary artery structure and stenosis using contrast media [9], while coronary angiography (CAG) remains the invasive gold standard for directly detecting vascular blockages [10].

The use of CAC scoring as an early risk stratification tool offers significant prognostic value, particularly for diabetic patients, by identifying those at higher risk of developing CAD before clinical symptoms emerge [11]. Understanding the factors related to CAC scores in this population is crucial for refining risk assessment and developing targeted interventions. Therefore, this study aims to analyse the determinants of calcium score values in patients with diabetes mellitus at risk of CAD, with the goal of improving cardiovascular disease prevention and management strategies in this vulnerable group.

Materials and Methods

Study design and participants. This study was an observational analytic study with a cross-sectional design. The research was conducted 1 year from January 2024 to January 2025 at RSUP Wahidin Sudirohusodo. A structured questionnaire was utilized to gather socio-demographic information from the study participants. The factors analyzed were gender, age, blood pressure, HbA1c value, BMI (body mass index), history of dyslipidemia, and family history of CAD. Anthropometric measurements – including height (in centimeters), weight (in kilograms), and body mass index (BMI) were obtained using standardized procedures and calibrated instruments. BMI was calculated by dividing body weight in kilograms by the square of height in meters (kg/m^2). HbA1c levels were measured using a standardized method by the National Glycohaemoglobin Standarization Program (NGSP) and the Diabetes Control and Complications Trial assay (DCCT).

Calcium Scoring Protocol Coronary artery calcium quantification was conducted using non-contrast ECG-gated computed tomography (CT) scans. The Agatston Score was used to classify the severity of calcified plaque as follows: Score 0: No plaque detected, Score: 1–10, Minimal plaque Score:11–100, Mild plaque Score: 101–400, Moderate plaque, Score >400. Extensive plaque burden. Patients with a calcium score exceeding 400 were considered at high risk and referred for further coronary angiography, where clinically indicated.

Sample and Eligibility Criteria. Samples were collected using consecutive sampling. Eligible subjects who met the inclusion criteria and visited the Cardiology Clinic at the Integrated Heart Center during the study period were consecutively recruited until the required sample size was achieved. Subjects who met the exclusion criteria were excluded from participation.

The inclusion criteria were all patients diagnosed with diabetes mellitus aged over 18 years attending the Cardiology Clinic at the Integrated Heart Center, Wahidin Sudirohusodo General Hospital, Makassar. Patients with a history of specific kidney diseases or chronic kidney disease, heart diseases other than coronary artery disease (such as valvular heart disease and congenital heart disease), and those with severe complications, including severe infections and organ failure –were excluded.

Ethical consideration. Ethical approval was obtained from the Health Research Ethics Committee of Hasanuddin University, Makassar, Indonesia, with the approval code/reference number [282/UN4.6.4.5.31/PP36/2025]. Informed consent was obtained from all participants (or their legal guardians if applicable) after a thorough explanation of the study objectives, procedures, risks, and benefits. Confidentiality and anonymity of the participants were ensured throughout the study, and data were used solely for research purposes.

Statistical analysis. Data were analyzed using SPSS for Windows, version 26.0. Statistical analysis included the Spearman correlation test, Chi-square test, and Mann-Whitney test, p-value <0.05 was considered statistically significant, indicating an association between the studied factors and calcium score values in diabetic patients. The results were presented in narrative form and supported by tables and figures.

Results. A total of 52 patients who met the inclusion criteria were initially enrolled in this study to assess the role of risk factors for increasing the Calcium Score in Diabetes patients. Baseline characteristics of the study population, including age, gender, BMI, blood pressure status, dyslipidemia, and CAC score categories, are summarized in table 1. The majority were men (65.4 %), while women accounted for 34.6 %. Most subjects were younger than 60 years (82.7 %), with only 17.3 % aged 60 years or older. In terms of body mass index (BMI), 28.8 % were classified as obese, while the remaining 71.2 % were non-obese. Hypertension was present in 54.5 % of the patients, and dyslipidemia was reported in 61.5 %, indicating a high burden of cardiovascular risk factors. A family history of coronary artery disease (CAD) was noted in 25 % of participants. Regarding coronary artery calcium (CAC) scores, the majority of patients fell into the high-risk category (61.5 %), followed by 36.5 % with mild risk, 1.9 % with low risk, and no patients with a score indicating no risk.

Table 2 summarizes the mean calcium scores in relation to gender, age, blood pressure status, history of dyslipidemia, and family history of coronary artery disease (CAD). Participants younger than 60 years exhibited a slightly higher mean score (443.30) compared to those aged 60 years and above (426.22); however, but this was not statistically significant (p = 0.748). Subjects with hypertension demonstrated a significantly higher mean calcium score (483.99) relative to those without hypertension (393.20) (p = 0.020). Although participants with a history of dyslipidemia had a higher mean score (461.19) than those without (406.99), this difference did not reach statistical significance (p = 0.185). Regarding body mass index (BMI), obese individuals had a lower mean calcium score (407.60) compared to non-obese subjects (453.62), though this difference was not significant. Patients with a family history of CAD showed a higher mean

Table 1

Characteristics of study population

Variables	Categorical	n	%
Gender	Woman	18	34.6
	Man	34	65.4
Age	<60 years	43	82.7
	⩾60 years	9	17.3
IMT	Non Obese	37	71.2
	Obese	15	28.8
Blood pressure	Hypertension	30	54.5
	Non Hypertension	25	45.5
Dyslipidemia	Yes	32	61.5
	No	20	38.5
CAD family history	Yes	13	25
	No	39	75
Calcium score	No risk	0	0
	Low	1	1.9
	Mild	19	36.5
	High	32	61.5

Table 2

Risk Factor Profiles Associated With Coronary Artery Calcium score in Diabetes Mellitus
**Independent T–Test*

Variables	Calcium score	n	Mean	SD	p
Gender	Man	34	440.85	127.53	0.985*
	Woman	18	440.07	151.96	
Age	<60 years	43	443.30	143.70	0.748*
	⩾60 years	9	426.22	145.39	
Blood pressure	Hypertension	27	483.99	152.47	**0.020***
	Non Hypertension	25	393.20	116.74	
Dyslipidemia	Yes	32	461.19	141.26	0.185*
	No	20	406.99	142.13	
IMT	Obese	15	407.60	65.89	0.297*
	Non Obese	37	453.62	162.88	
CAD Family History	Yes	13	482.54	109.54	0.217*
	No	39	426.13	150.70	

score (482.54) compared to those without such a history (426.13), but not statistical significance (p = 0.217).

The results of the correlation between HbA1c level and calcium score (Figure 1). Spearman's correlation analysis revealed a statistically significant positive relationship between Total Calcium score and HbA1c levels (r = 0.317; p = 0.022). This indicates that higher HbA1c values are associated with higher coronary artery calcium scores, although the strength of this correlation is relatively weak.

Discussion. This study was conducted among diabetic patients, of whom 65.4 % were male and 82.7 % were under 60 years of age, indicating that cardiovascular risk in diabetes is substantial even among younger adults. This is consistent with data from the American Diabetes Association, which reports higher macrovascular complications in men and early atherosclerosis onset in younger diabetics due to prolonged hyperglycemia exposure [12]. Similar findings were reported by Santos-Gallego et al., demonstrating early coronary calcification in young diabetic population [13].

Despite a predominance of non-obese individuals (71.2 %), high coronary artery calcium (CAC) scores were frequent, supporting the concept of metabolically obese normal weight (MONW) individuals, as described in previous studies [14,15]. Hypertension was observed in 54.5 % of subjects, reinforcing its role as a major contributor to vascular calcification. Whelton et al. previ-

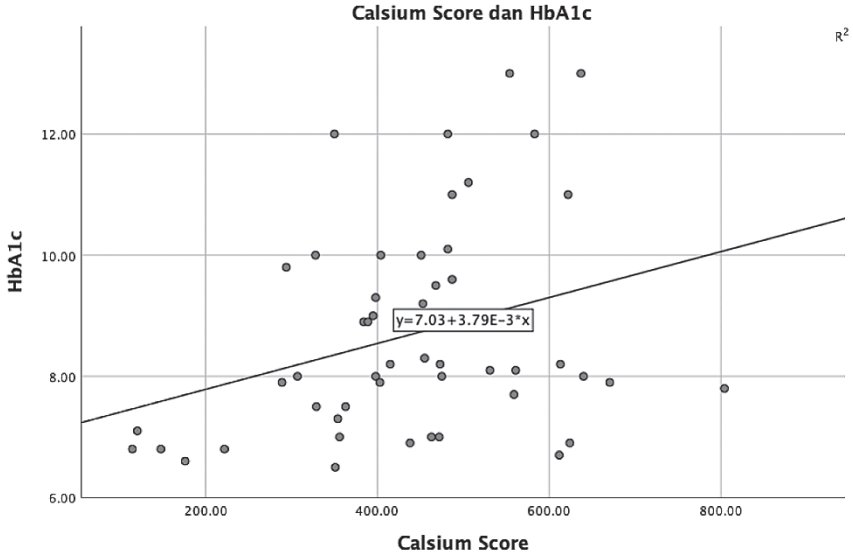

Figure 1. *Correlation between HbA1C level and Calcium score (r = 0.317; p = 0.022)*

ously demonstrated a twofold increase in coronary risk among diabetics with hypertension [16]. Dyslipidemia was also prevalent (61.5 %), consistent with previous studies that underscored its central role in plaque formation and calcification [13]. Notably, despite only 25 % of participants reporting a family history of coronary artery disease (CAD), elevated CAC scores were widespread, emphasizing the predominant role of modifiable risk factors over genetics [16].

Our study showed a significant positive correlation between HbA1c and CAC score ($r = 0.317$, $p = 0.022$), supporting previous studies linking glycaemic control to vascular calcification. This correlation, although weak, indicates that higher HbA1c levels – as an indicator of long-term glycaemic control – are associated with higher coronary calcium scores, which reflect the degree of calcification or subclinical atherosclerosis in the coronary arteries. These findings confirm that poor glycaemic control in diabetic patients may be a key factor in accelerating the process of vascular calcification, which marks the early stages of coronary heart disease.

Physiologically, high and prolonged blood glucose levels cause oxidative stress, activation of inflammatory pathways, and endothelial dysfunction, all of which contribute to the formation of atherosclerotic plaque and arterial calcification. Hyperglycemia also increases the production of advanced glycation end products (AGEs), which enhance calcium deposition on the blood vessel wall. Guyton and Hall (2021) explained that AGEs and chronic inflammatory reactions accelerate vascular damage typical of diabetic patients. Therefore, HbA1c as a chronic glycemic marker has predictive value for the progression of atherosclerosis. Zhang et al. [17] demonstrated accelerated CAC progression in patients with HbA1c ≥8 %, while the last study confirmed HbA1c as an independent predictor of CAC, even after adjusting for other risk factors [18,19]. The modest correlation observed in this study may reflect the multifactorial nature of calcification [20].

Multivariate analysis revealed hypertension and HbA1c as the strongest predictors of CAC score, while dyslipidaemia, BMI, age, and family history were not significant. These findings align with those of Saeed et al. and Al-Mallah et al., who reported that metabolic and haemodynamic factors, rather than traditional risk markers, primarily drive calcification in diabetic populations [19,16]. Although a statistically significant positive correlation was observed between HbA1c and total CAC score ($r = 0.317$; $p = 0.022$), the strength of this association was weak to moderate. This finding underscores that while poor glycaemic control contributes meaningfully to coronary calcification, diabetes alone is not the sole determinant. Other metabolic and haemodynamic factors likely interact to influence the development and progression of subclinical atherosclerosis in this population.

Strengths and Limitations. The strengths of this study include the comprehensive assessment of multiple cardiovascular risk factors and their relationship with coronary artery calcium (CAC) scores in a real-world diabetic population. The inclusion of both inpatient and outpatient subjects provides a broader perspective on disease burden. Additionally, the use of CAC scoring, an established and validated predictor of cardiovascular events, strengthens the clinical relevance of the findings. The analysis also incorporated multivariate models to adjust for potential confounders, enhancing the robustness of the associations observed between hypertension, HbA1c, and CAC scores.

However, several limitations should be acknowledged. First, the cross-sectional design precludes causal inferences and limits the ability to assess progression over time. Second, the sample size was relatively modest, which may have reduced the statistical power to detect associations with variables such as dyslipidemia and BMI. Third, data on medication use, including statins and antihypertensive agents, were not fully controlled, which could have influenced CAC scores. Additionally, factors such as diabetes duration, physical activity, and dietary patterns were not included, which may confound the relationship between metabolic factors and vascular calcification. Lastly, the study population was derived from a single center, which may limit generalizability to other populations.

Conclusions. This study found that HbA1c is an independent predictor of coronary artery calcium (CAC) score in diabetic patients, with hypertension also exerting a significant influence. Although the correlation between HbA1c and CAC was statistically significant, its weak-to-moderate strength suggests that diabetes is a key, but not exclusive, contributor to coronary calcification. These findings underscore the multifactorial nature of atherosclerosis and highlight the importance of comprehensive cardiovascular risk assessment beyond glycaemic control alone.

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Authors' Contributions

RA: Validation, visualization, formal analysis, writing – original draft. KS: Conceptualization, writing–review & editing. MA: Conceptualization, software, supervision, validation, visualization, writing–review & editing. AZ.: Data curation, investigations.

Conflict of Interest

The authors declare no conflicts of interest related to the research, authorship, or publication of this article.

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Фактори ризику, пов'язані з показником коронарного кальцію у хворих на діабет

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Резюме

Вступ. Цукровий діабет (ЦД) пов'язаний із значним підвищенням ризику розвитку коронарної хвороби серця (КХС) через механізми судинної кальцифікації та атеросклерозу. Оцінка кальцію в коронарних артеріях (САС) є надійним, неінвазивним методом для раннього виявлення субклінічного атеросклерозу у пацієнтів з підвищеним серцево-судинним ризиком.

Мета. Проаналізувати взаємозв'язок між факторами серцево-судинного ризику та показниками CAC у пацієнтів із діабетом.

Матеріали та методи. Поперечне дослідження включало 52 дорослих пацієнти з діабетом, які проходили обстеження в Кардіологічній клініці Загальної лікарні Вахідін Судірохусодо, Індонезія. Збиралися дані про демографічні характеристики, індекс маси тіла (ІМТ), показники артеріального тиску, наявність дисліпідемії, сімейний анамнез КХС, а також рівень HbA1c. Оцінка кальцію проводилась методом безконтрастної, ЕКГ-синхронізованої комп'ютерної томографії з подальшою класифікацією за шкалою Агатстона. Для статистичного аналізу застосовували кореляційний тест Спірмена, непараметричний тест Манна-Уітні та багатовимірний регресійний аналіз.

Результати. Більшість пацієнтів були чоловіками (65,4 %) і молодшими за 60 років (82,7 %). Високі показники CAC (>400) спостерігались у 61,5 % пацієнтів. Було виявлено значущий позитивний кореляційний зв'язок між рівнем HbA1c та загальним CAC ($r = 0,317$; $p = 0,022$). У багатовимірному аналізі HbA1c залишався незалежним предиктором підвищених значень CAC ($p < 0,05$), при цьому гіпертонія також була значущою у часткових моделях. Інші фактори, зокрема ІМТ, дисліпідемія, вік і сімейний анамнез КХС, статистично значущого зв'язку з CAC не мали.

Висновки. Кальцифікація коронарних артерій часто зустрічається серед пацієнтів із діабетом, включаючи молодих і не ожирілих осіб. HbA1c і гіпертонія є ключовими предикторами кальцифікаційного навантаження. Ці результати підкреслюють необхідність оптимального контролю глікемії та артеріального тиску, а також врахування скринінгу CAC для ранньої стратифікації серцево-судинного ризику у діабетичних пацієнтів.

Ключові слова: *цукровий діабет, коронарна хвороба серця, кальцієвий бал, гіпертонія, HbA1c.*

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