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MAMMOGRAPHIC BREAST ARTERIAL CALCIFICATIONS AND THEIR ASSOCIATION WITH CORONARY ARTERY CALCIFICATION SEVERITY AND DISTRIBUTION IN SAUDI WOMEN

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Abstract

Background: Breast arterial calcifications (BAC) detected on mammography have been associated with systemic vascular disease, but their relationship with coronary artery calcifications (CAC) remains underexplored in regional populations. This study assessed the association between BAC severity and CAC severity, distribution, and multi-vessel coronary involvement in Saudi women while accounting for age, hypertension (HTN), and diabetes mellitus (DM).
Methods: This retrospective study included 60 women aged 40–88 years who underwent digital mammography and chest CT within the same year. BAC and CAC were graded visually using standard radiologic criteria. Ordinal logistic regression assessed the association between BAC severity and CAC severity after adjustment for age, HTN, and DM. Fisher's exact test evaluated CAC artery distribution and multi-vessel involvement, with additional stratified analyses by HTN and DM status. Analyses were performed using IBM SPSS Statistics version 27.
Results: BAC was present in 33.3% of participants, while CAC was identified in 21.7%. Mild BAC showed a borderline association with increasing CAC severity after adjustment ($p = 0.054$), whereas moderate and severe BAC were not statistically significant. Women aged 60–69 years had significantly greater CAC severity than those aged 40–49 years ($p = 0.036$). Significant unadjusted associations were found between BAC severity and CAC artery distribution ($p = 0.020$) and multi-vessel CAC involvement ($p = 0.007$). Stratified analyses by HTN and DM revealed no significant subgroup differences.
Conclusions: BAC severity was associated with CAC distribution and unadjusted multi-vessel coronary involvement in Saudi women. Although adjusted analyses showed only a borderline association with CAC severity, BAC may serve as a useful adjunct marker for identifying women who could benefit from cardiovascular risk assessment.

Keywords: breast arterial calcification; coronary artery calcification; cardiovascular risk; mammography; Saudi women; vascular calcification.

INTRODUCTION

Cardiovascular disease (CVD), particularly coronary artery disease (CAD), continues to be the leading cause of death among women globally, accounting for more than 9 million deaths each year (Tsao et al., 2022). Coronary artery calcifications (CAC), a well-established marker of subclinical atherosclerosis, is commonly assessed using computed tomography (CT) and provides valuable prognostic information regarding future cardiovascular events (Gupta et al., 2022; Iribarren et al., 2022). However, the widespread use of CAC scoring is limited by cost, accessibility, and radiation exposure, especially in asymptomatic individuals and low-resource settings.

Breast arterial calcifications (BAC), often incidental findings on routine screening mammography, represent medial arterial calcification and have been increasingly recognized for their potential role as surrogate indicators of systemic vascular pathology (Hendriks et al., 2015). Several studies have demonstrated associations between BAC and various cardiovascular conditions, including coronary artery disease, heart failure, and stroke (Kemmeren et al., 1998; Rotter et al., 2008; Iribarren, Chandra et al., 2022). As mammography is widely used for breast cancer screening, BAC offers a unique opportunity to leverage existing imaging data for cardiovascular risk assessment without additional cost or radiation burden.

Emerging evidence has further supported the clinical relevance of BAC through advancements in automated quantification and artificial intelligence (AI)-driven imaging models (Jeong et al., 2023; Allen et al., 2024; American College of Cardiology, 2025; ScienceDaily, 2025). These technologies have increased both the reproducibility and diagnostic yield of BAC evaluation, prompting calls to integrate BAC reporting into routine mammography interpretation. In addition, studies such as those by Yurdaışık and Nurili, 2020 and Ryan, et al. 2017 have shown that BAC severity is positively associated with CAC burden and may help identify patients with multi-vessel coronary disease (Ryan et al., 2017; Yurdaışık et al., 2020).

Despite these promising findings, there remains a gap in the literature regarding the association between BAC and coronary calcification burden in non-Western populations. Saudi Arabia, with a high prevalence of diabetes, hypertension, and obesity—key risk factors for vascular calcifications—presents a relevant setting to further explore this relationship. There is a need for region-specific data to understand whether BAC can serve as a reliable marker for coronary calcifications in this population.

This study aimed to assess whether the severity of BAC observed on digital mammography correlates with the severity and anatomical distribution of CAC on chest CT in Saudi women aged 40 years and older. Additionally, the study explored the association between BAC severity and multi-vessel coronary involvement and examined the potential influence of age, hypertension, and diabetes on the BAC–CAC relationship.

METHODS

Study Design and Setting

This retrospective cross-sectional study was conducted at a tertiary academic hospital in Jeddah, Saudi Arabia. It aimed to investigate the relationship between breast arterial calcification (BAC), as identified through digital mammography, and coronary artery calcification (CAC), assessed through chest computed tomography (CT). Given the growing importance of preventive cardiovascular care and rehabilitation, the study also explored whether routinely identified vascular calcifications on mammography could support cardiovascular risk stratification in women undergoing standard breast imaging.

Study Population

The study included a total of 60 women aged 40 to 88 years who underwent both digital mammography and chest CT within the same calendar year. Inclusion criteria were: (1) female sex, (2) age ≥40 years, and (3) availability of both imaging modalities performed within 12 months. Exclusion criteria included a history of coronary artery disease or revascularization procedures, poor image quality, or incomplete imaging or clinical data. This sample was extracted from an initial pool of over 900 screened records.

Imaging Evaluation

Breast Arterial Calcification (BAC): BAC was assessed by two board-certified radiologists using digital mammography. The presence and severity of BAC were graded using a standard visual scale: none, mild, moderate, or severe. BAC was defined as linear or tram-track calcifications following arterial pathways. Inter-reader discrepancies were resolved through consensus review.

Coronary Artery Calcification (CAC): Non-contrast chest CT scans were evaluated for CAC across four coronary territories: left anterior descending (LAD), left circumflex (LCX), right coronary artery (RCA), and left main (LM). CAC severity was scored visually as none, mild, moderate, or severe per artery. The number of involved arteries (range 0–4) was recorded, and multi-vessel disease was defined as calcification in ≥2 coronary arteries. All chest CT examinations were non-contrast studies interpreted by experienced radiologists blinded to mammographic BAC findings.

Clinical and Demographic Data

Demographic and clinical data—including age group (in decades), hypertension (HTN), diabetes mellitus (DM), dyslipidemia, and smoking history—were collected from patient records. These variables were included in adjusted and stratified analyses.

Statistical Analysis

All analyses were performed using IBM SPSS Statistics version 27 (IBM Corp., Armonk, NY, USA). Continuous variables were summarized using means and standard deviations, while categorical variables were presented as frequencies and percentages.

To evaluate the association between BAC severity and CAC severity, ordinal logistic regression analysis was performed after adjustment for age group, hypertension, and diabetes mellitus. Reference categories were BAC severity = none and age group = 40–49 years. Model fitting information, goodness-of-fit statistics, pseudo R^2 values, and parameter estimates were reported. The proportional odds assumption was assessed using the Test of Parallel Lines; however, due to sparse data and convergence limitations, the test could not be reliably estimated.

Because several contingency table cells contained small expected frequencies, Fisher's exact test was used instead of Pearson chi-square testing to evaluate associations between BAC severity and CAC artery distribution as well as multi-vessel CAC involvement. To improve statistical validity, CAC artery involvement was recoded into three categories: 0 arteries, 1 artery, and ≥2 arteries involved.

Given the limited number of multi-vessel CAC events, multivariable logistic regression analysis was not performed to avoid model instability and overfitting. Stratified analyses according to hypertension and diabetes status were additionally conducted using Fisher's exact testing to explore potential to explore subgroup differences in the BAC–CAC relationship. A two-sided p-value <0.05 was considered statistically significant.

RESULTS

Patient Characteristics

A total of 60 women aged between 40 and 88 years (mean ± SD: 55.88 ± 11.0) were included (Table 1). The most represented age groups were 40–49 years (33.3%) and 50–59 years (30.0%). Most participants had no documented cardiovascular risk factors, while 11.7% had hypertension, 10.0% had diabetes mellitus, 3.3% had dyslipidemia, and 1.7% were smokers.

Prevalence and Severity of BAC and CAC

Breast arterial calcification (BAC) was present in 33.3% of participants: 11.7% mild, 11.7% moderate, and 10.0% severe. Coronary artery calcification (CAC) was identified in 21.7%: 10.0% mild, 8.3% moderate, and 3.3% severe. The left anterior descending artery was the most frequently involved coronary territory.

Ordinal Association Between BAC Severity and CAC Severity

Ordinal logistic regression analysis was performed to evaluate the association between BAC severity and CAC severity after adjustment for age group, hypertension, and diabetes mellitus. The final model demonstrated acceptable overall fit. Mild BAC severity demonstrated a borderline association with increasing CAC severity (p = 0.054), whereas moderate and severe BAC severity were not statistically significant. Patients aged 60–69 years demonstrated significantly greater CAC severity compared with patients aged 40–49 years (p = 0.036).

Association Between BAC Severity and CAC Distribution

Due to small expected cell frequencies, Fisher's exact test was used instead of Pearson chi-square testing to evaluate the association between BAC severity and CAC artery distribution. A statistically significant association was identified between BAC severity and CAC distribution (Fisher exact test, p = 0.020).\

Association Between BAC Severity and Multi-Vessel CAC

Due to the limited number of multi-vessel CAC events, multivariable logistic regression analysis was not performed to avoid model instability and overfitting. Fisher's exact test demonstrated a statistically significant association between BAC severity and multi-vessel CAC involvement (p = 0.007). Increasing BAC severity was associated with a higher proportion of patients demonstrating involvement of two or more coronary arteries.

Stratified Analysis According to Hypertension and Diabetes

Stratified analyses according to hypertension and diabetes status were performed using Fisher's exact testing to explore subgroup differences in the BAC–CAC relationship. No statistically significant subgroup associations were observed.

DISCUSSION

Correlation with CAC Severity and Distribution

The present study demonstrated a significant association between BAC severity and CAC artery distribution using Fisher's exact testing ($p = 0.020$). Patients with higher BAC grades demonstrated a greater frequency of involvement of two or more coronary arteries, suggesting a pattern of more extensive vascular calcification. These findings are consistent with studies by Ryan et al. (2017) and Yurdaışık and Nurili (2020), which reported positive associations between BAC burden and coronary calcium extent.

Although adjusted ordinal regression analysis did not demonstrate statistically significant associations for moderate or severe BAC categories, mild BAC severity showed a borderline association with increasing CAC severity after adjustment for age, hypertension, and diabetes mellitus. Additionally, patients aged 60–69 years demonstrated significantly greater CAC severity compared with younger age groups, emphasizing the important contribution of aging to vascular calcification burden.

Association Between BAC Severity and Multi-Vessel CAC

The observed association between BAC severity and multi-vessel CAC involvement suggests that increasing BAC burden may reflect more extensive coronary calcification. However, due to the limited number of multi-vessel CAC events, adjusted multivariable regression analysis was not performed to avoid model instability and overfitting. These findings remain consistent with prior studies suggesting that BAC may serve as an adjunct imaging marker associated with coronary calcification burden (Schnatz et al., 2011).

Subgroup Analyses and Clinical Relevance

Stratified analyses according to hypertension and diabetes status did not demonstrate statistically significant subgroup differences in the BAC–CAC relationship. However, the findings continue to support the potential clinical relevance of BAC as an adjunct imaging marker that may assist cardiovascular risk stratification during routine mammographic screening. Recent AI-enhanced mammography studies by Allen et al. (2024) and Jeong et al. (2023) further support the growing role of BAC assessment in population-based cardiovascular screening strategies.

Study Strengths and Limitations

This study contributes novel data from a Middle Eastern cohort, a population with high prevalence of metabolic risk factors and limited representation in cardiovascular imaging research. It benefits from matched imaging modalities and adjusted ordinal regression analyses. However, limitations include its retrospective design, modest sample size, and lack of lipid and inflammatory marker data, which could influence vascular calcification. Additionally, sparse data and the limited number of multi-vessel CAC events restricted the use of more complex multivariable modeling and may have reduced statistical power for subgroup analyses (ScienceDaily, 2025).

Clinical Recommendation

In summary, BAC identified on routine mammography was associated with CAC artery distribution and unadjusted multi-vessel CAC involvement in this cohort of Saudi women. Although adjusted ordinal regression analyses did not demonstrate statistically significant associations for moderate or severe BAC categories, BAC may still serve as a valuable adjunct imaging marker for identifying women who may benefit from cardiovascular risk assessment, particularly in patients not routinely undergoing cardiac imaging.

We recommend incorporating BAC evaluation into routine mammographic reports for women aged 40 years and above, especially in regions with high cardiometabolic disease burden. This approach could provide clinicians with a low-cost, non-invasive tool for enhanced cardiovascular risk stratification and early intervention.

CONCLUSION

This study demonstrated significant associations between breast arterial calcification (BAC) severity and coronary artery calcification (CAC) distribution detected via chest computed tomography (CT) in Saudi women aged 40 years and older. Although adjusted ordinal regression analyses showed only a borderline association between mild BAC severity and increasing CAC severity after adjustment for age, hypertension, and diabetes mellitus, higher BAC grades were associated with greater coronary artery involvement on Fisher's exact testing. These findings support the potential role of BAC as an adjunct imaging marker for identifying women who may benefit from cardiovascular risk assessment.

The findings suggest that incorporating BAC assessment into routine mammographic evaluations could enhance early identification and management of women at increased risk for coronary artery disease. Given the widespread use of mammography for breast cancer screening, the incidental detection of BAC offers a cost-effective and non-invasive opportunity to improve cardiovascular risk stratification without additional radiation exposure.

However, the study's retrospective design and relatively small sample size limit the generalizability of the results. Additionally, sparse data and the limited number of multi-vessel CAC events restricted the use of more complex multivariable modeling. Future prospective studies with larger and more diverse populations are warranted to validate these findings and further explore the relationship between BAC and systemic vascular calcification.

Ethical approval and consent to participate

This study is in accordance with the principles of the Declaration of Helsinki. Approval was issued by the Research Ethics Committee of the of the Faculty of Medicine, King Abdulaziz University (Approval No. HA-02-J-008). Given the retrospective design, the requirement for informed consent was waived, and strict patient confidentiality was maintained.

Disclosure

The authors have no conflicts of interest to disclose. None of the authors received outside funding for the production of this original manuscript and no part of this article has been previously published elsewhere.

Data availability

The data that support the findings of this study is available upon reasonable request from the corresponding author.

Author contributions

LKA: Concept and design of the study, drafting the article and revising it critically for important intellectual content.

LGJ: Acquisition of data, analysis and interpretation of data, drafting the article and revising it critically for important intellectual content.

Both authors approved the final version of the manuscript and are accountable for aspects of the work that questions related to the accuracy or integrity of any part of the work are appropriately investigate and resolved.

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Table 1. Demographic and Cardiovascular Risk Characteristics of the Study Population.

Variable	N	%
Total	60	100.0
40–49 years	20	33.3
50–59 years	18	30.0
60–69 years	14	23.3
≥70 years	8	13.3
HTN	7	11.7
DM	6	10.0
Dyslipidemia	2	3.3
Smoking	1	1.7
None	50	83.3

Table 2. Distribution and Severity of Coronary and Breast Arterial Calcifications.

Variable	N (%)
CAC Present - Yes	13 (21.7)
CAC Severity - Mild	6 (10.0)
CAC Severity - Moderate	5 (8.3)
CAC Severity - Severe	2 (3.3)
Multi-vessel CAC	7 (11.7)
BAC Present - Yes	20 (33.3)

BAC Severity - Mild	7 (11.7)
BAC Severity - Moderate	7 (11.7)
BAC Severity - Severe	6 (10.0)

Table 3. Ordinal Logistic Regression Analysis of Factors Associated with CAC Severity.

Variable	Estimate	S.E.	95% CI	P-value
Mild BAC	2.035	1.055	-0.033 to 4.104	0.054
Moderate BAC	1.087	1.010	-0.892 to 3.066	0.282
Severe BAC	1.435	1.189	-0.894 to 3.765	0.227
Age 50–59	0.614	1.338	-2.008 to 3.236	0.646
Age 60–69	2.603	1.239	0.174 to 5.031	0.036a
Age ≥70	2.163	1.449	-0.676 to 5.002	0.135
HTN	0.889	1.101	-1.270 to 3.048	0.420
DM	0.946	1.315	-1.632 to 3.525	0.472

a-significant at <0.05 level using Ordinal Logistic Regression.

Table 4. Model Assessment for Ordinal Logistic Regression.

Assessment	Value
Chi-square	18.244
df	8
p-value	0.019a
Pearson p-value	0.990
Deviance p-value	0.987
Cox and Snell	0.262
Nagelkerke	0.339
McFadden	0.205

a-significant at <0.05 level using Ordinal Logistic Regression.

Table 5. Association Between BAC Severity and CAC Distribution Using Fisher's Exact Test.

BAC Severity	Total	0 arteries	1 artery	≥2 arteries
None	40	35 (87.5%)	4 (10.0%)	1 (2.5%)
Mild	7	5 (71.4%)	0 (0.0%)	2 (28.6%)
Moderate	7	4 (57.1%)	1 (14.3%)	2 (28.6%)
Severe	6	3 (50.0%)	1 (16.7%)	2 (33.3%)
Total	60	47 (78.3%)	6 (10.0%)	7 (11.7%)

Likelihood Ratio = 11.63; Fisher Exact Test p-value = 0.020; a-significant using Fisher Exact Test at <0.05 level.