



**ASSOCIATION BETWEEN BREAST ARTERIAL CALCIFICATIONS FOUND ON MAMMOGRAPHY AND INCREASED RISK OF CORONARY ARTERY CALCIFICATIONS IN ASIAN POPULATIONS: A LITERATURE REVIEW**

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**ABSTRACT**

Mammography examination of the breast has been widely used throughout the world, but many findings found through this modality have been overlooked, one of which is breast arterial calcification (BAC). Breast cancer is often experienced by millions of women in the world, signs are usually screened for breast cancer using mammography. This literature review aims to assess the association between BAC found on mammography and increased risk of coronary artery calcifications in Asian populations. An initial search was carried out using reference sources from the electronic databases PubMed, Scopus, Cochrane, Wiley, ScienceDirect, EBSCOhost, and Google Scholar, using keywords "mammography", "breast arterial calcification", and "coronary artery disease" with their synonyms. Titles and abstracts were reviewed for relevance, followed by full-text screening, without any time limitation (until September 21th, 2023). The inclusion criteria was study published in English that assess BAC on mammography with the risk of coronary arterial calcifications in Asian. This review included a total of eight studies, which included a total of 2735 patients. Research was conducted in several countries in Asia, including Saudi Arabia, Nepal, Iran, China, South Korea, and Turkey, using cohort and cross-sectional research methods. BAC+ women were significantly older than BAC- women ( $P=0.001$ ), and there was a strong association between BAC and CACS ( $P = 0.0001$ ). The sign of BAC on mammography may contribute as a non-invasive marker of cardiovascular risk, especially in Asian populations. However, lack of a standardized BAC scoring system might limit its application. Breast artery calcification significantly increases the incidence of cardiac artery disease in Asian populations, which can be assessed by mammography and requires further attention from physicians.

Keywords: breast arterial calcification; breast cancer; mammography

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**INTRODUCTION**

Mammography examination of the breast has been widely used throughout the world, but many findings found through this modality have been overlooked, one of which is breast arterial calcification (BAC). These findings are often overlooked, particularly in diagnosing cardiovascular disease. Breast cancer is often experienced by millions of women in the world, signs are usually screened for breast cancer using mammography. It was reported that 47.5% of women aged 40 to 49 years and 57.2% of women between the ages of 50 and 74 underwent mammograms in 2011 (Pace et al., 2013; Quispe et al., 2019). However, its utilization of mammography is usually limited only

to breast cancer; no routine screening for coronary artery disease (CAD) based on CAD mammography has also affected millions of people. Additionally, compared with men, women have been shown to have worse outcomes when CAD is confirmed (M Dewey, 2022; Xie et al., 2017). Cardiovascular disease has also been highlighted as the number one killer worldwide. Recent data confirms that cardiovascular disease is the main cause of death among women, accounting for approximately one-third of deaths (Roth et al., 2018).

Recent studies have shown that BAC in particular has also been directly associated with an increased risk of acute myocardial infarction, although observations have not provided consistent results (Bui & Daniels, 2019). Some concerns have also been raised regarding the lack of improvement in the prevention of cardiovascular disease in women. The mortality rate for heart failure is higher in women than in men, which has shown the urgency of the wide recognition of findings found in mammography (L. R. Margolies et al., 2019). Until now, mammography has often been done in clinical settings. However, the awareness regarding its complications and predictive value, BAC, for instance, has to be acknowledged and researched further. One interpretation of BAC's findings that is emerging as one of the important things to note is the increased risk of cardiovascular disease.

Some studies show an increased risk of cardiovascular disease among BAC-positive women when adjusted for age and conventional risk factors. Studies have shown that breast artery calcification (BAC) measurements have the potential to provide a personalized and non-invasive approach to stratifying the risk of cardiovascular disease in women, such as heart attack and stroke (Quispe et al., 2019). As heart disease is still considered the number one killer in the world, prevention is an issue, and several ways need to be addressed to measure the prognosis of developing CAD in the future. As mammography is regularly performed, especially in developed countries, combined with the predictable potential role of BAC in cardiovascular disease shown by studies, mammography could potentially be used as a surrogate screening method for cardiovascular disease, making it easier to perform.

Asia as one of the biggest regions worldwide, has different characteristics compared to Hispanics or other populations. We believe that radiological findings and their implications are often location-specific. Therefore, although several reviews have tried to assess the relationship between BAC and CAD prediction, and several studies have tried to analyze the relationship between BAC; however, no review has established the potential risk stratifying method using BAC for CAD prediction in the Asian population (Benjamin et al., 2019). Thus, this literature review aims to assess the association between breast arterial calcifications found on mammography and increased risk of coronary artery calcifications in Asian populations, therefore explaining the diagnostic picture. It is hoped that this literature could become a reference for researchers to explore this topic further in the future and could open knowledge regarding the importance of paying attention to BAC more, regarding its meaning in clinical practice.

## **METHOD**

An initial literature review was carried out using reference sources from the electronic databases PubMed, Scopus, Cochrane, Wiley, ScienceDirect, EBSCOhost, and Google Scholar. Kinds of literature published within the last 10 years were included in this study. The search was carried out until September 21, 2023. Literature was searched with the keywords "Mammography", "Breast Arterial Calcification", and "Coronary Artery Disease" with their synonyms. The inclusion criteria in this review are as follows: (1) Literature regarding Breast Arterial Calcification in patients undergoing examination mammography for Coronary Artery Disease, (2) The literature assesses the relationship between Breast Arterial Calcification in patients who do mammography examination for Coronary Artery Disease, (3) Literature with cross-sectional, case-control, cohort and clinical trial designs, both randomized and non-randomized, (4) Studies conducted in Asia, (5) Women patient who does mammography as their participant, (6) Breast Arterial calcification as their intervention, (7) Woman with risk factors as their control, and (8) BAC Score >11, risk of CAD as

their outcome. Studies that include pediatric patients (<18 years), literature beyond the past 10 years, complete articles that cannot be accessed, and articles outside English and Indonesian were excluded from this review.

The initial search was then continued with a review using the title and abstract method to assess the relevance of the literature. Relevant studies were reviewed by reading the full text and assessed based on conformity to the inclusion criteria. These results were then reviewed by the five authors (AWP, TK, DA, EN, BWU), and if there was disagreement between the authors, it would be mediated by two authors (AGIK and AW). Differences of opinion will then be discussed further until a consensus is reached.

## RESULT

Overall, this review included a total of eight studies (from 742 articles in initial search), which included a total of 2735 patients. Research was conducted in several countries in Asia, including Saudi Arabia, Nepal, Iran, China, South Korea, and Turkey, using cohort and cross-sectional research methods. Detailed characteristics of the included studies are summarized in Table 1.

Table 1. Study Characteristics and Outcome

Author, year	Country	Design	Subjects	Methodology	Results
Fathala, 2018 (Fathala et al., 2018)	Saudi Arabia	Retrospective cohort	307 women who underwent mammography and CACS assessment using CT scan.	BAC: BAC score from assessment mammograms CACS: semi-automatic calculation of all main coronary arteries.	BAC was present in 46% of all subjects.  BAC correlated strongly with CACS ( $P=.0001$ ), diabetes ( $P=.0001$ ), hypertension ( $P=.021$ ), CKD ( $P=.0031$ ), and age ( $P=.001$ ).
Jha, 2021 (Jha et al., 2021)	Nepal	Cross-sectional descriptive study	1614 mammograms from 20 to 89 year old women, which were obtained over four months in a teaching hospital.	BAC evaluation of mammograms by radiologists with more than ten years of experience. CACS: not done	BAC was present in 11.6% patients  The incidence and severity of BAC increased along with patients' age.
Seifi, 2020 (Seifi et al., 2020)	Iran	Cross-sectional	60 women over 40 years old who underwent CT angiography screening.	BAC: Evaluation of the number, density, and length of calcified vessels in the mammograms CACS: calculation using a guideline from the Cardiac Society of Australia and New Zealand.	BAC significantly correlated with CACS ( $p = 0.001$ ), as well as CAD risk factors such as diabetes, hypertension, and hyperlipidemia ( $p < 0.0001$ ).

Author, year	Country	Design	Subjects	Methodology	Results
Huang, 2020 (Huang et al., 2020)	China	Retrospective cohort	213 asymptomatic women aged more than 40 years old who underwent CCTA and mammograms between July 2018 and April 2019.	BAC: assessed from mammograms by radiologists with 10 years of experience, defined as “absent” or “present”  CAD-RADS: deep learning model using 2000 CT angiography scans.	The presence of BAC significantly predicted a CAD-RADS score of $\geq 3$ (OR = 5.1; 95% CI = 45.1-86.1)
Yoon, 2019 (Yoon et al., 2019)	South Korea	Cross-sectional	2100 women aged 40 years old or more who underwent digital mammography, DXA, and CCTA between March 2011 and February 2013.	BAC: determined using a scoring system, evaluated from full-field digital mammograms by a radiologist with 8 years of experience.  CACS: evaluated from CT angiogram results using the Agaston scoring system.	BAC presence and severity were predictors of CAC and CAP
Yıldız, 2016 (Yıldız et al., 2016)	Turkey	Cohort retrospective	A total of 120 premenopausal women aged 40 years old or older who underwent mammography procedures from January to November 2015.	BAC: mammograms with BAC in any projections were defined as BAC (+).  Cardiovascular risk predictors: examinations with 12-lead electrocardiogram, echocardiography, and serum TC, TG, and HDLc assays..	BAC was positively and significantly correlated with non-HDLc level ( $r = 0.202$ , $p = 0.027$ ) and LDLc level ( $r = 0.188$ , $p = 0.039$ ), but had a significant and negative correlation with HDLc level ( $r = 0.223$ , $p = 0.014$ )
Happy, 2022 (Happy et al., 2022)	Turkey	Cross-sectional	70 females who underwent mammography	BAC: assessment using a four-point scale based on digital mammogram findings by at least two of three trained radiologists.  CAC: assessed by a semi-automated software using the Agaston method.	BAC had strong diagnostic accuracy in predicting CAC.
Hanafi, 2018 (Hanafi et al., 2018)	Iran	Case-control	60 female patients who were admitted and underwent CT angiography.	BAC: evaluated using the four-point BAC grading from two-view mammograms by an expert radiologist.  CAC: determined using the Agaston criteria based on the coronary CT angiogram results	Patients with BAC had a higher risk of developing CAC (OR = 13; 95% CI = 3.5 - 47.6, RR = 4.33; 95% CI = 1.73 - 10.8).

Abbreviations: BAC= breast arterial calcification; CAD= Coronary Artery Diseases; CTA= Coronary Computed Tomography Angiography; CCTA= Coronary Computed Tomography Angiography.

A literature review found an association between BAC and increased risk of CAD, especially in Asian populations. A study by Happy et al demonstrated that BAC can predict CHD and growth transients in coronary atherosclerosis as demonstrated by CCTA. BAC is also closely associated with the development of coronary artery calcification (CAC) and coronary atherosclerotic plaque (CAP). According to the calculation of the diagnostic accuracy table for breast artery calcification of mammography for predicting the presence of existing coronary artery disease, the sensitivity value is 26.3% and the specificity is 82.3% (Happy et al., 2022). This finding is supported by a study from Hanafi et al., among 60 Iranian women in 36 patients (60%) had BAC, and 26 patients (72%) had CAD. There is a significant correlation between BAC and CAD. The sensitivity and specificity of BAC for CAD were 69% and 47%. Additionally, CAD patients had significantly higher severe BAC scores than non-CAD patients. NPV and PPV are 83% and 72%, respectively (Hanafi et al., 2018).

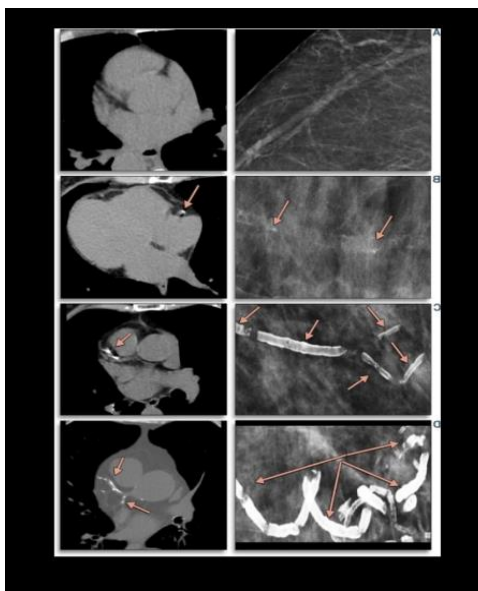


Figure 1. Mechanism of BAC predicting CAD based on its pathophysiology

Additionally, Huang et al. evaluated the association of BAC in mammographic breast screening with the Coronary Artery Disease Reporting and Data System (CAD-RADS). In this study, 213 women were included. BAC was found in 22 women (10.3%), of which 23 were classified as CAD-RADS  $\geq 3$ , indicating a positive correlation between the severity of CAD and the presence of BAC in women who underwent breast screening mammography (OR 10.22, 95% CI 2.86–36.49,  $P < 0.001$ ) (Huang et al., 2020). A study by Seifi et al. supported these findings by showing that there was a significant correlation between coronary artery calcification and breast artery calcification ( $p = 0.001$ ) and between coronary artery calcification and postmenopausal calcification ( $p < 0.001$ ) (Seifi et al., 2020).

Another cross-sectional study by Jha et al. also found that BAC prevalence increased with age. A total of 188 mammograms among 1,614 female patients aged 20 to 89 years had BAC. All patients aged 80 to 89 years had calcifications on mammographic examination (Jha et al., 2021). In a study conducted by Fathala et al, BAC was detected in 142 patients. BAC was found to be significantly more common in older women than younger women ( $p = 0.001$ ), and there was a strong association between BAC and coronary artery calcium score (CACS) ( $p = 0.0001$ ). Additionally, a strong correlation was found between the components of BAC and CACS score ( $p < 0.001$ ). Multivariate linear regression analysis showed that age and CAC were strong predictors of BAC (Fathala et al., 2018).

A cohort study by Fathala et al. also found that BAC was detected in 142 (46%) patients in the study group. BAC+ women were significantly older than BAC- women ( $P=0.001$ ), and there was a strong association between BAC and CACS ( $P = 0.0001$ ). However, no association was found between BAC and a family history of coronary artery disease. Additionally, a strong correlation was found between CACS and BAC score components ( $P < 0.001$ ) (Fathala et al., 2018). Seifi et al. found that the number and degree of vascular calcification in the breast increased as patients aged. If breast artery calcification is present, this should be mentioned in the mammography report. Identification of these calcifications on mammography may lead to further screening for atherosclerosis (Seifi et al., 2020). This is consistent with the study by Yoon et al. The presence of BAC can be a predictor of CAC and CAP (Yoon et al., 2019). Additionally, Yildiz et al. concluded that BAC is a potentially useful tool for detecting dyslipidemia and early atherosclerosis in premenopausal women (Yıldız et al., 2016).

## **DISCUSSION**

This literature review found that patients with BAC were associated with the incidence of CAD in Asian populations. There have been many literature reviews which state that BAC is a risk factor for CAD. Ahmed et al showed in their research results that among women who underwent screening with mammography. This incident is linked to heart problems (Deeg et al., 2024; Fathala et al., 2018). We will further discuss the use of digital mammography and how BAC can predict the incidence of CAD based on pathophysiology.

### **Digital Mammography and its Current Utilization**

Digital mammography examination was carried out in the mediolateral oblique and craniocaudal positions. Assessment is divided into 3 categories. First, the incidence of impaired vessels in the breast is given a score of 1 to 6. If more than 6 blood vessels are involved, then the maximum score is still given as 6. Second, the length of the blood vessels that have BAC. If there are no blood vessels involved, then a score of 0 is given; if the affected vessel is no more than one-third of its length, it is given a point of 1; if it is less than two-thirds, it is given a point of 2; and if it is more than two-thirds, it is given a point of 3. Third, assess calcium density in blood vessels with BAC. If there are no calcified blood vessels, a score of 0 is given, if the density is light with good visualization of the blood vessels and/or calcification in only one blood vessel the score is 1, if the density is moderate with blurred visualization of the blood vessels and calcified the wall of blood vessel the score is 2, and if the density was severe and the vessel lumen could not be visualized the score is 3. The total scores from the three categories are classified into 3 groups based on the value range: 0, 1 to 3, and 4 to 12 (L. Margolies et al., 2016).

### **Vascular Calcification Pathophysiology**

Anatomically, two parts of the blood vessel walls can experience calcification: the tunica intima and tunica media. Calcification in the tunica intima is associated with atherosclerosis. The process is similar to bone formation, involving matrix proteins, growth factors, and bone-associated proteins. Other cells are also involved, such as inflammatory cells, vascular smooth muscle cells, and lipid deposits. Meanwhile, tunica media calcification (Mönckeberg-type calcification) occurs without lipid deposits or macrophages. This is also related to several diseases such as diabetes mellitus, kidney disease, degenerative and genetic diseases (Okşul et al., 2023).

The BAC calcifications are more often localized in the tunica media. Calcification of the tunica media is more diffuse, spreading to small arteries. Meanwhile, calcification of the tunica intima usually occurs in the main arteries or larger arteries and is located separately. However, in fact, both are difficult to differentiate using x-ray examination or digital mammography (Vos et al., 2022). A study by Jha A, et al, concluded that BAC is more often found in the tunica media than the intima. The visualization of calcification in the tunica media appears more linear or like a tram-track that is dense, rough, and joins to fill the lumen of blood vessels. The incidence of BAC also occurs more often in patients who have diabetes mellitus, kidney disease, coronary heart disease, a history of

pregnancy, and breastfeeding (Jha et al., 2021). Kadioğlu's study also supports the discovery of two rather linear lines with a parallel line connecting the two. Apart, BAC also occurs more often in women over 50 years of age (Kadioğlu & Bahadır, 2022). Another study found that calcification in the tunica media increases the probability of heart disease, especially in patients with metabolic diseases of the pancreas and kidneys. This is because calcification in the tunica media will result in loss of arterial elasticity so that the arteries become stiff (Vos et al., 2022)

### **Associations of Cardiovascular Risk Factors with Breast Arterial Calcification**

A meta-analysis study, reported an association between arterial calcification and an increased probability of developing cardiovascular disease (Koh et al., 2023). Middle artery calcification (MAC) based on the mechanism of occurrence is also called Monckeberg's sclerosis. In contrast to arterial calcification in the intima, it is found in medium to large-sized arteries, which is also called typical atherosclerosis (Monaco et al., 2025; Nikolajević & Šabovič, 2023). The stiffness caused by MAC is the main factor that can explain BAC and the incidence of heart and blood vessel disorders (Nikolajević & Šabovič, 2023).

Several studies do not show a consistent relationship between BAC and CAD. However, BAC is associated as a risk factor for various metabolic and degenerative diseases (Koziol & Frishman, 2024). Onnis et al differentiate between arterial calcification in the breast and coronary arteries, where CAC occurs mainly on the surface of the vessels and is associated with atherosclerosis (Onnis et al., 2024). In principle, BAC occurs due to medial sclerosis. Therefore, atherosclerosis in the breast arteries is difficult to assess using conventional examination alone (Park & Avolio, 2023).

Some studies have suggested an association between BAC with old age, hypertension, hypertriglyceridemia, body mass index problems, homocysteine, and hs-CRP. It is known that a high glycemic index stimulates the production of osteogenic proteins, such as Gla matrix, osteocalcin, and osteoprotegerin. This will result in calcium accumulation in the tunica media (Upadhyay & Kumar, 2025).

Pregnancy and the breastfeeding phase have been found to increase the probability of arterial calcification in the breast. This can occur due to the increased need for calcium for breast milk and fetal growth. A protein that is useful for bone growth (Osteocalcin) is found in calcified blood vessels because its levels increase in the first month of breastfeeding (Lee et al., 2022). An association has also been found between BAC and osteoporosis. Decreased bone calcium density, which is replaced by sodium, occurs in osteoporosis and BAC patients. Likewise, the finding that women in Japan after menopause is closely related to the incidence of osteoporosis in the spine (Kim et al., 2022).

Although this review suggests that BAC discovered by mammography is associated with an increased probability of CAC primarily in Asian populations, our study also has limitations. There are several obstacles in this journal, including the lack of international standardization regarding the BAC score as a trigger factor for arterial calcification. In addition, we recommend more research related to this topic in Asia and Southeast Asia, so that the research results can be implemented further, especially in Indonesia.

### **CONCLUSION**

In conclusion, breast artery calcification significantly increases the incidence of cardiac artery disease in Asian populations, which can be assessed by mammography and requires further attention from physicians. This relationship is also influenced by age. The possibility of coronary artery disease increases in patients who experience arterial calcification in their breasts. Further multidisciplinary research is needed on this topic. We recommend that future research focus more on patients and collaborate with women's health departments. It is important to remember that BAC is not only observed as a tumor marker, but has value as a predictive factor for CAD as well. It is important to encourage healthcare physicians to further discuss BAC and its atherosclerotic

management with each patient. Future research should be conducted prospectively. In short, every clinician who encounters a BAC case must report and analyze it comprehensively, especially the patient's cardiovascular health as well.

## REFERENCES

- Benjamin, E. J., Muntner, P., Alonso, A., Bittencourt, M. S., Callaway, C. W., Carson, A. P., Chamberlain, A. M., Chang, A. R., Cheng, S., Das, S. R., Delling, F. N., Djousse, L., Elkind, M. S. V., Ferguson, J. F., Fornage, M., Jordan, L. C., Khan, S. S., Kissela, B. M., Knutson, K. L., ... Virani, S. S. (2019). Heart Disease and Stroke Statistics—2019 Update: A Report From the American Heart Association. *Circulation*, 139(10). <https://doi.org/10.1161/CIR.0000000000000659>
- Bui, Q. M., & Daniels, L. B. (2019). A Review of the Role of Breast Arterial Calcification for Cardiovascular Risk Stratification in Women. *Circulation*, 139(8), 1094–1101. <https://doi.org/10.1161/CIRCULATIONAHA.118.038092>
- Deeg, J., Swoboda, M., Bilgeri, V., Lacaita, P. G., Scharll, Y., Luger, A., Widmann, G., Gruber, L., & Feuchtner, G. M. (2024). Does the absence of breast arterial calcification (BAC 0) rule out severe coronary artery disease? A computed tomography angiography study. *American Journal of Preventive Cardiology*, 19, 100724. <https://doi.org/10.1016/j.ajpc.2024.100724>
- Fathala, A. L., Alabdulkarim, F. M., Shoukri, M., & Alanazi, M. (2018). Association between breast arterial calcifications found on mammography and coronary artery calcifications in asymptomatic Saudi women. *Annals of Saudi Medicine*, 38(6), 433–438. <https://doi.org/10.5144/0256-4947.2018.433>
- Hanafi, M. G., Zadeh, M. S., Momeni, M., & Rajabkordi, S. (2018). Relationship between breast arterial calcification on mammography with coronary CT angiography findings. *Frontiers in Biology*, 13(4), 309–313. <https://doi.org/10.1007/s11515-018-1510-6>
- Happy, H., E-Mahabub, S. M. E., Mollah, N. U., Hossain, Md. E., Khatun, Dr. H., & Rahman, Md. M. (2022). Breast Arterial Calcification on Mammography and Risk of Coronary Artery Disease. *Scholars Journal of Applied Medical Sciences*, 10(5), 810–815. <https://doi.org/10.36347/sjams.2022.v10i05.023>
- Huang, Z., Xiao, J., Xie, Y., Hu, Y., Zhang, S., Li, X., Wang, Z., Li, Z., & Wang, X. (2020). The correlation of deep learning-based CAD-RADS evaluated by coronary computed tomography angiography with breast arterial calcification on mammography. *Scientific Reports*, 10(1), 11532. <https://doi.org/10.1038/s41598-020-68378-4>
- Jha, A., Sah, A., Joshi, B. R., & Lohani, B. (2021). Breast Arterial Calcifications on Mammography among Patients Attending the Radiology Department in a Tertiary Care Centre: A Descriptive Cross-sectional Study. *Journal of Nepal Medical Association*, 59(241), 844–847. <https://doi.org/10.31729/jnma.6922>
- Kadioğlu, A., & Bahadır, S. (2022). Breast arterial calcifications as an indicator of atherosclerotic cardiovascular disease: comparative analysis of coronary computed tomography scoring systems and carotid intima-media thickness. *Quantitative Imaging in Medicine and Surgery*, 12(1), 457–469. <https://doi.org/10.21037/qims-21-98>
- Kim, K. M., Yoon, Y. E., Yun, B. La, & Suh, J.-W. (2022). Association between Bone Mineral Density and Coronary Atherosclerotic Plaque According to Plaque Composition: Registry for the Women Health Cohort for Bone, Breast, and Coronary Artery Disease Study. *Journal of Bone Metabolism*, 29(2), 123–131. <https://doi.org/10.11005/jbm.2022.29.2.123>
- Koh, T. J. W., Tan, H. J. H., Ravi, P. R. J., Sng, J. W. Z., Yeo, T.-C., Tan, B. Y. Q., Chai, P., Yeo, L. L. L., Chan, M. Y., Kong, W. K. F., Wong, R. C. C., Teo, Y. H., Ho, J. S. Y., Teo, Y. N., & Sia, C.-H. (2023). Association Between Breast Arterial Calcifications and Cardiovascular Disease: A Systematic Review and Meta-analysis. *Canadian Journal of Cardiology*, 39(12), 1941–1950. <https://doi.org/10.1016/j.cjca.2023.07.024>
- Koziol, K. J., & Frishman, W. H. (2024). Incidental Breast Arterial Calcifications and Assessment of Coronary Artery Disease Risk: A Review and Recommendation. *Cardiology in Review*, 32(6), 519–527. <https://doi.org/10.1097/CRD.0000000000000567>

- Lee, S. C., Pirikahu, S., Phillips, M., Bellinge, J., Stone, J., Wylie, E., Stuckey, B. G. A., & Schultz, C. (2022). Reproductive factors and breast arterial calcification: a systematic review and meta-analysis. *Climacteric*, 25(2), 147–154. <https://doi.org/10.1080/13697137.2021.1985991>
- M Dewey. (2022). Comparative effectiveness of initial computed tomography and invasive coronary angiography in women and men with stable chest pain and suspected coronary artery disease: multicentre randomised trial. *BMJ*, e071133. <https://doi.org/10.1136/bmj-2022-071133>
- Margolies, L. R., Yip, R., Hwang, E., Oudsema, R. H., Subramaniam, V. R., Hecht, H., & Narula, J. (2019). Breast Arterial Calcification in the Mammogram Report: The Patient Perspective. *American Journal of Roentgenology*, 212(1), 209–214. <https://doi.org/10.2214/AJR.18.20171>
- Margolies, L., Salvatore, M., Hecht, H. S., Kotkin, S., Yip, R., Baber, U., Bishay, V., Narula, J., Yankelevitz, D., & Henschke, C. (2016). Digital Mammography and Screening for Coronary Artery Disease. *JACC: Cardiovascular Imaging*, 9(4), 350–360. <https://doi.org/10.1016/j.jcmg.2015.10.022>
- Monaco, C., McNamara, C. A., Slütter, B., Foks, A. C., Bekiranov, S., Mulder, W. J. M., Gonçalves, I., & Lutgens, E. (2025). Immunotherapy for atherosclerosis. *Physiological Reviews*. <https://doi.org/10.1152/physrev.00016.2024>
- Nikolajević, J., & Šabovič, M. (2023). Inflammatory, Metabolic, and Coagulation Effects on Medial Arterial Calcification in Patients with Peripheral Arterial Disease. *International Journal of Molecular Sciences*, 24(4), 3132. <https://doi.org/10.3390/ijms24043132>
- Okşul, M., Şener, Y. Z., Sarıkaya, Y., Sarıkaya, S., Yıldırım, A., Canpolat, U., Akpınar, M. G., Hazirolan, T., Özer, N., & Tokgözoğlu, S. L. (2023). Breast artery calcification as an opportunistic predictor of cardiovascular disease. *Irish Journal of Medical Science (1971 -)*, 192(2), 625–631. <https://doi.org/10.1007/s11845-022-03127-2>
- Onnis, C., Virmani, R., Kawai, K., Nardi, V., Lerman, A., Cademartiri, F., Scicolone, R., Boi, A., Congiu, T., Faa, G., Libby, P., & Saba, L. (2024). Coronary Artery Calcification: Current Concepts and Clinical Implications. *Circulation*, 149(3), 251–266. <https://doi.org/10.1161/CIRCULATIONAHA.123.065657>
- Pace, L. E., He, Y., & Keating, N. L. (2013). Trends in mammography screening rates after publication of the 2009 US Preventive Services Task Force recommendations. *Cancer*, 119(14), 2518–2523. <https://doi.org/10.1002/ncr.28105>
- Park, J. B., & Avolio, A. (2023). Arteriosclerosis and Atherosclerosis Assessment in Clinical Practice: Methods and Significance. *Pulse*, 11(1), 1–8. <https://doi.org/10.1159/000530616>
- Quispe, R., Al-Rifai, M., Di Carlo, P. A., Michos, E. D., Amin, N. P., Kianoush, S., Handy, C. E., McEvoy, J. W., Blaha, M. J., Nasir, K., Blumenthal, R. S., Tota-Maharaj, R., Lima, J. A. C., Comin-Colet, J., & Cainzos-Achirica, M. (2019). Breast Arterial Calcium. *JACC: Cardiovascular Imaging*, 12(12), 2538–2548. <https://doi.org/10.1016/j.jcmg.2018.07.035>
- Roth, G. A., Abate, D., Abate, K. H., Abay, S. M., Abbafati, C., Abbasi, N., Abbastabar, H., Abd-Allah, F., Abdela, J., Abdelalim, A., Abdollahpour, I., Abdulkader, R. S., Abebe, H. T., Abebe, M., Abebe, Z., Abejie, A. N., Abera, S. F., Abil, O. Z., Abraha, H. N., ... Murray, C. J. L. (2018). Global, regional, and national age-sex-specific mortality for 282 causes of death in 195 countries and territories, 1980–2017: a systematic analysis for the Global Burden of Disease Study 2017. *The Lancet*, 392(10159), 1736–1788. [https://doi.org/10.1016/S0140-6736\(18\)32203-7](https://doi.org/10.1016/S0140-6736(18)32203-7)
- Seifi, B., Javadrashid, R., Seifi, F., Khamanian, J., Zarrintan, A., & Mirza-Aghazadeh-Attari, M. (2020). Breast artery calcification as a predictor of coronary artery calcification: a cross-sectional study. *Polish Journal of Radiology*, 85, 369–374. <https://doi.org/10.5114/pjr.2020.97932>
- Upadhyay, P., & Kumar, S. (2025). Diabetes and Bone Health: A Comprehensive Review of Impacts and Mechanisms. *Diabetes/Metabolism Research and Reviews*, 41(5). <https://doi.org/10.1002/dmrr.70062>
- Vos, A., Vink, A., Kockelkoren, R., Takx, R. A. P., Celeng, C., Mali, W. P. T. M., Isgum, I., Bleys, R. L. A. W., & de Jong, P. A. (2022). Radiography and Computed Tomography Detection of

- Intimal and Medial Calcifications in Leg Arteries in Comparison to Histology. *Journal of Personalized Medicine*, 12(5), 711. <https://doi.org/10.3390/jpm12050711>
- Xie, J. X., Eshtehardi, P., Varghese, T., Goyal, A., Mehta, P. K., Kang, W., Leipsic, J., ó Hartaigh, B., Bairey Merz, C. N., Berman, D. S., Gransar, H., Budoff, M. J., Achenbach, S., Callister, T. Q., Marques, H., Rubinshtein, R., Al-Mallah, M. H., Andreini, D., Pontone, G., ... Shaw, L. J. (2017). Prognostic Significance of Nonobstructive Left Main Coronary Artery Disease in Women Versus Men. *Circulation: Cardiovascular Imaging*, 10(8). <https://doi.org/10.1161/CIRCIMAGING.117.006246>
- Yıldız, A., Seçen, Ö., Yıldız, C., & Çiçekçi, M. (2016). Relationship between breast arterial calcification and lipid profile, plasma atherogenic index, Castelli's risk index and atherogenic coefficient in premenopausal women. *IJC Metabolic & Endocrine*, 11, 19–22. <https://doi.org/10.1016/j.ijcme.2016.05.003>
- Yoon, Y. E., Kim, K. M., Han, J. S., Kang, S.-H., Chun, E. J., Ahn, S., Kim, S. M., Choi, S. Il, Yun, B. La, & Suh, J.-W. (2019). Prediction of Subclinical Coronary Artery Disease With Breast Arterial Calcification and Low Bone Mass in Asymptomatic Women. *JACC: Cardiovascular Imaging*, 12(7), 1202–1211. <https://doi.org/10.1016/j.jcmg.2018.07.004>