

Incidental Tomographic Findings of Coronary Artery Calcifications: A Prevalence Study in Southern Brazil

Karen Rafaela Okaseski Scopel,¹ Tássia Machado Medeiros,^{1,2} Bibiana Natalia Porto Maicá,¹ Maria Carbonari Velho,¹ Mariana Motta Dias da Silva,³ Juliane Nascimento Mattos,² Guilherme Galante Heuser,^{1,2} Eliane Roseli Winkelmann¹

Universidade Regional do Noroeste do Estado do Rio Grande do Sul (UNIJUI),¹ Ijuí, RS – Brazil

Hospital Noroeste Unimed/RS,² Ijuí, RS – Brazil

Universidade Federal do Rio Grande do Sul (UFRGS),³ Porto Alegre, RS – Brazil

Abstract

Introduction: Coronary artery calcifications (CAC) are shown to be a predictive factor of cardiovascular diseases. Computed tomography (CT) of the chest with a low-dose acquisition protocol is accurate in identifying CAC and provides incidental findings of these calcifications, which are commonly overlooked. This study will analyze the prevalence of incidental findings of calcification in coronary arteries in non-cardiac individuals undergoing chest CT.

Methods: Consecutive cross-sectional study of an analytical and descriptive nature. Individuals of both genders who underwent chest CT by referral, over 18 years of age and without heart disease were included. Data collection was carried out using medical records and a self-applied anamnesis form. The variables referring to the CAC and the extension of the impairment were obtained from the reassessment of the chest CT images available in the institution's system. The exams were anonymized and evaluated by two experienced radiologists. $P \leq 0.05$ was considered statistically significant.

Results: 397 exams were analyzed. A prevalence of calcifications was found in 176 (44%) of the cases. The existence of these coronary calcifications is related to age ($p < 0.001$). Calcifications are related to gender ($p = 0.03$) with a higher odds ratio of development in men (odds ratio [OR] = 1.55). Smoking ($p < 0.001$), sedentary lifestyle ($p < 0.001$), systemic arterial hypertension ($p < 0.001$), Diabetes Mellitus ($p = 0.04$), and dyslipidemia ($p < 0.001$) showed a positive association.

Conclusion: The prevalence of incidental CAC findings was 44%; vary in greater numbers between mild and severe; higher odds ratio in males and increased prevalence with age. Therefore, chest CT proves to be an effective method to assess CAC, and together with the patient's clinical history, it can be used to measure risk factors for CVD and intervene in the outcome of the condition.

Keywords: Tomography, X-Ray Computed; Incidental Findings; Vascular Calcification; Coronary Vessels.

Introduction

Cardiovascular diseases (CVD) are among the main health problems in the world and, therefore, they should be prevented.¹ Thus, coronary artery calcifications (CAC), initially asymptomatic, have proven to be an alarming and predictive factor for these diseases.² They are characterized by a progressive and gradual pathophysiological process, which results in abnormal vasomotor responses and/or narrowing of the vessel lumen. These changes are strongly associated with advanced age, diabetes mellitus (DM),

dyslipidemia, systemic arterial hypertension (SAH), male gender, and smoking.³

Computed tomography (CT) of the chest, used with low-dose acquisition protocols, was 97.13% accurate in identifying CAC and proved to be effective in detecting or excluding them.⁴ This test, usually used for pulmonary diagnostic purposes, has been providing frequent incidental findings of calcifications, since there are cardiovascular conditions that can cause non-cardiac symptoms, such as dyspnea, chest pain, and hemoptysis. Thus, studies on these findings have been gaining space in the clinical and scientific scope.²

Despite the confirmation of the negative impacts of coronary calcifications, incidental cardiac findings on chest CT are still commonly neglected.⁵⁻⁷ Thus, the prevalence of incidentalomas and their clinical relevance have been estimated in several studies and based on different contexts.^{8,9} However, there are no studies of this nature in the northwest region of the state of Rio Grande do Sul; therefore, this research aimed to fill a gap regarding population-based information on the region under study in the clinical and scientific fields. In this perspective, the objective was to analyze the prevalence

Correspondência: Eliane Roseli Winkelmann •

Universidade Regional do Noroeste do Estado do Rio Grande do Sul (UNIJUI). Rua do Comércio, 2000. CEP: 98700-000. Bairro Universitário, Ijuí, RS – Brasil.

E-mail: elianew@unijui.edu.br

Manuscript received December 10, 2022; revised January 11, 2022; accepted January 16, 2023.

Editor responsible for the review: Leonardo Sara Silva.

DOI: <https://doi.org/10.36660/abcimg.2023368i>

of incidental findings of calcification in coronary arteries in non-cardiac patients undergoing chest CT.

Methods

Participants

This is a cross-sectional study of analytical and descriptive nature, developed in based on the Guidelines and Regulatory Norms for Research Involving Human Beings, in accordance with the Resolution of the National Health Council (*Conselho Nacional de Saúde* – CNS) No. 466/12 and approved by the Research Ethics Committee of UNIJUI (CAAE: 84431118.2.0000.5350). Individuals of both genders who underwent chest CT by referral were included. Individuals under 18 years of age, exams performed by referral from a cardiac physician, exams with technical difficulties for image evaluation and duplicate exams, that is, two or more exams performed by the same patient within an interval of less than 6 months, were excluded.

Data collection

It was carried out in medical records of a Hospital in the Northwest region of the state of Rio Grande do Sul, Brazil, between March 27th and October 5th, 2019. The variables age, gender, associated comorbidities (SAH, DM, and dyslipidemia), family history of heart disease, previous history of heart disease (Heart Failure, Acute Myocardial Infarction), smoking, physical inactivity, and the patient's symptomatology were collected from a self-administered anamnesis form with closed questions.

The variables referring to calcifications of the left coronary, left anterior descending, circumflex, and right coronary arteries, as well as the extent of their impairment, were obtained from the reassessment of the chest CT images available on the Picture Archiving and Communication System (PACS) (<https://www.animati.com.br/animati-workstation/>) of the institution. Also in this system, the reason for the medical referral to perform the examination described in the reports was obtained. Data were compiled by a single researcher for better quality and standardization of information.

Acquisition and Interpretation of Images

The device used to perform the exams was a 32-slice Alexion CT scanner (Toshiba, Otawara, Japan) using a low-dose acquisition protocol. The examinations were performed with the patient in the supine position and in apnea. The chest images were analyzed in axial sections, in soft tissue window and only in the non-contrast phase. The exams were anonymized (Advantage Workstation, version 4.6. GE Healthcare) so that previous data did not influence the analyses and the evaluators were completely blinded regarding the patient and each other. The analyses were performed by two previously trained radiologists with more than 5 years of experience in the area. First, the images were evaluated independently by the professionals. The images that showed disagreement between physicians were reanalyzed converging on a consensual result.

Coronary calcification score by visual scale

Following the protocol performed by Shemesh et al.,¹⁰ four coronary arteries were evaluated: left main, left anterior descending, circumflex, and right. Each of them was classified and scored as absent (0), mild (1), moderate (2), or severe (3). It was characterized as mild when less than one third of the length of the entire artery was compromised, moderate when there were calcifications in one to two thirds of the artery, and severe when more than two thirds of the artery was calcified. After scoring, the results were added up, classified into: absent (0), mild (1-3), moderate (4-6), and severe (7-12).

Statistical analysis

Data collection was performed using Microsoft Office Excel 2010 and analysis using R Studio software (version 3.4.4). For the analysis of descriptive statistics, relative and absolute frequency, measures of central tendency and dispersion, were used. In the analytical statistics of the qualitative variables, the χ^2 test was used to test the hypothesis of dependence between the variables as well as to verify the adherence between them, considering statistically significant $p \leq 0.05$. In the analytical statistics of the quantitative variables, the prevalence of calcification findings was estimated. To determine the number of classes for the age variable, the Sturges Rule was used.

Inter-examiner agreement was estimated using Cohen's Kappa and the reference values for analysis described by Landis and Koch.¹¹ For the normality verification analysis, the Kolmogorov Smirnov test was used for the age variable along with the non-parametric Mann Whitney U test, considering statistically significant $p \leq 0.05$. The odds ratio was used to estimate the presence of calcification in relation to its predisposing variables.

Results

A total of 397 exams were analyzed, showing substantial inter-examiner agreement ($\kappa = 0.77$). Patients had a mean age of 61.88 ± 16.26 years, with a predominance of females (52.14%). The commonly found reasons for referral were: changes in the respiratory system ($n = 94$), monitoring of a pulmonary nodule ($n = 47$), and lung cancer ($n = 27$).

Sedentary lifestyle (69.02%) and family history of heart disease (44.84%) are the most worrying among the main risk factors, while cancer is the leader in relation to previous diseases, reaching 38.29% of cases, followed by SAH (46.85%), with a higher prevalence in females (Table 1).

The population characterized above showed a prevalence of calcifications in 176 (44%) of the cases and it was found that the presence or absence of these coronary calcifications is related to age ($p < 0.001$). A greater occurrence of calcifications was observed in the age group between 76 and 84 years. However, the highest prevalence of calcification was from 92 to 100 years (100%), being more severe. Furthermore, it was possible to note that there is an increasing prevalence of calcifications above 68 years of age, reaching more than 60% of patients (Table 2). In the score used for the analysis of the arteries, seen in isolation, it was possible to verify that

Table 1 – Description of predisposing factors for the formation of arterial calcifications

	Female N = 207	Male N = 190	Total N = 397
Age mean±SD, years	61.18±15.92	62.64±16.63	61.88±16.26
Risk factors, N (%)			
Smoking	55 (13.85)	85 (21.41)	140 (35.26)
Sedentarism	153 (38.54)	121 (30.48)	274 (69.02)
Family history of heart disease	102 (25.69)	76 (19.14)	178 (44.84)
Family History of SAH	131 (33)	103 (25.94)	34 (58.94)
Prior Diseases, N (%)			
Cancer	73 (18.39)	79 (19.90)	152 (38.29)
Acute myocardial infarction	7 (1.76)	8 (2.02)	15 (3.78)
Cardiac insufficiency	17 (4.28)	21 (5.29)	38 (9.57)
Comorbidities, N (%)			
SAH	101 (25.44)	85 (21.41)	186 (46.85)
DM	24 (6.05)	24 (6.05)	48 (12.10)
Dyslipidemias	48 (12.09)	49 (12.34)	97 (24.43)

SD: standard deviation; SAH: Systemic Arterial Hypertension; DM: Diabetes Mellitus.

Table 2 – Visual scale analysis of coronary calcifications and their prevalence

Age	Absent	Mild	Moderate	Severe	Prevalence
18 I-27	11	0	0	0	0.00
27 I-35	15	0	0	0	0.00
35 I-43	28	4	0	0	0.13
43 I-51	31	3	0	2	0.14
51 I-59	39	13	0	2	0.28
59 I-68	44	20	11	5	0.45
68 I-76	36	31	11	13	0.60
76 I-84	11	18	7	14	0.78
84 I-92	6	6	8	5	0.76
92 I-101	0	0	0	3	1.00
Total	221	95	37	44	0.44

Table 3 – Relation of predisposing factors with coronary calcifications and the odds ratio of occurrence

Characteristics	p-value*	OR†	(95%)CI
Gender	0.03	-	-
Female	-	0.64	(0.42 - 0.98)
Male	-	1.55	(1.02 - 2.37)
Smoking	<0.001	2.45	(0.26 - 0.64)
Sedentarism	<0.001	2.97	(0.20 - 0.55)
Family history of heart disease	0.92	1.03	(0.64 - 1.48)
Family History of SAH	0.22	1.30	(0.50 - 1.18)
Cancer	0.47	1.17	(0.56 - 1.32)
SAH	<0.001	3.45	(0.19 - 0.45)
DM	0.04	1.93	(0.27 - 1.00)
Dyslipidemias	<0.001	2.65	(0.23 - 0.62)

* χ^2 Test; † Odds Ratio; CI: confidence interval; SAH: Systemic Arterial Hypertension.

the most compromised artery was the right coronary, in 193 (48.61%) of the cases.

Calcifications are related to gender ($p = 0.03$) with a higher odds ratio of development in men (odds ratio [OR] = 1.55). Still on the variables that influence the development of calcifications, smoking ($p < 0.001$), sedentary lifestyle ($p < 0.001$), SAH ($p < 0.001$), DM ($p = 0.04$), and dyslipidemia ($p < 0.001$) showed a positive association, with SAH (OR = 3.45) and sedentary lifestyle (OR = 2.97) having the highest odds ratio (Table 3). The results of the prevalence of CAC and the degree in relation to the age groups are graphically illustrated in Figure 1. Figure 2 represents the main findings of the study.

Discussion

The present study observed a 44% prevalence of incidental findings of CAC on chest CT in patients asymptomatic for heart disease, which increases with age and with greater chances of developing in males. It can also be observed that there is a direct relationship with risk factors and associated comorbidities, both closely linked to daily living habits. Regarding the diagnostic method, its effectiveness in the clinical and scientific scope can be seen, as in previous studies.

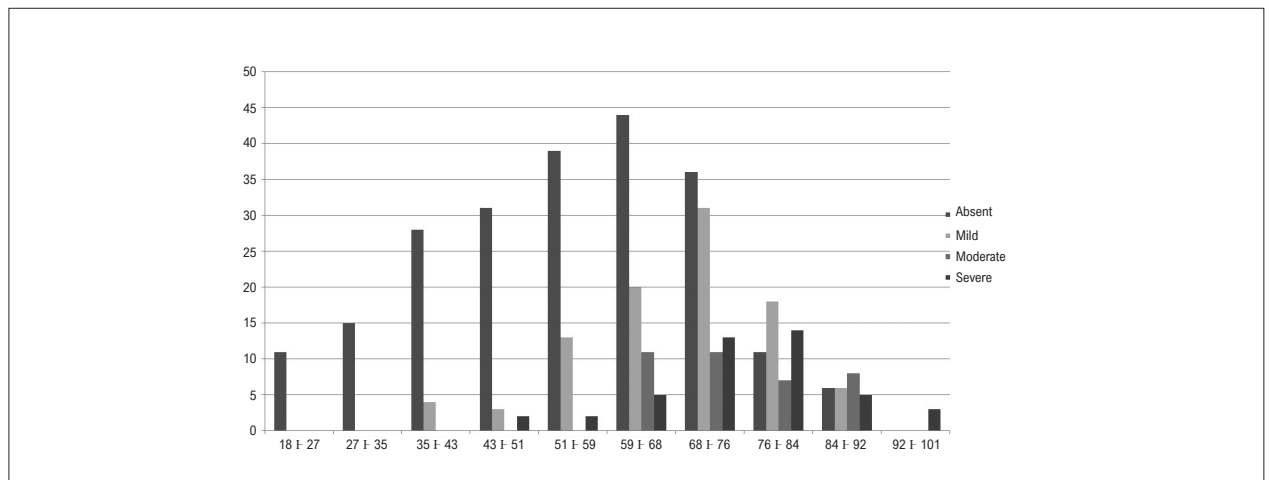


Figure 1 – Graphical representation of the prevalence of CAC and the degree of involvement in relation to age.

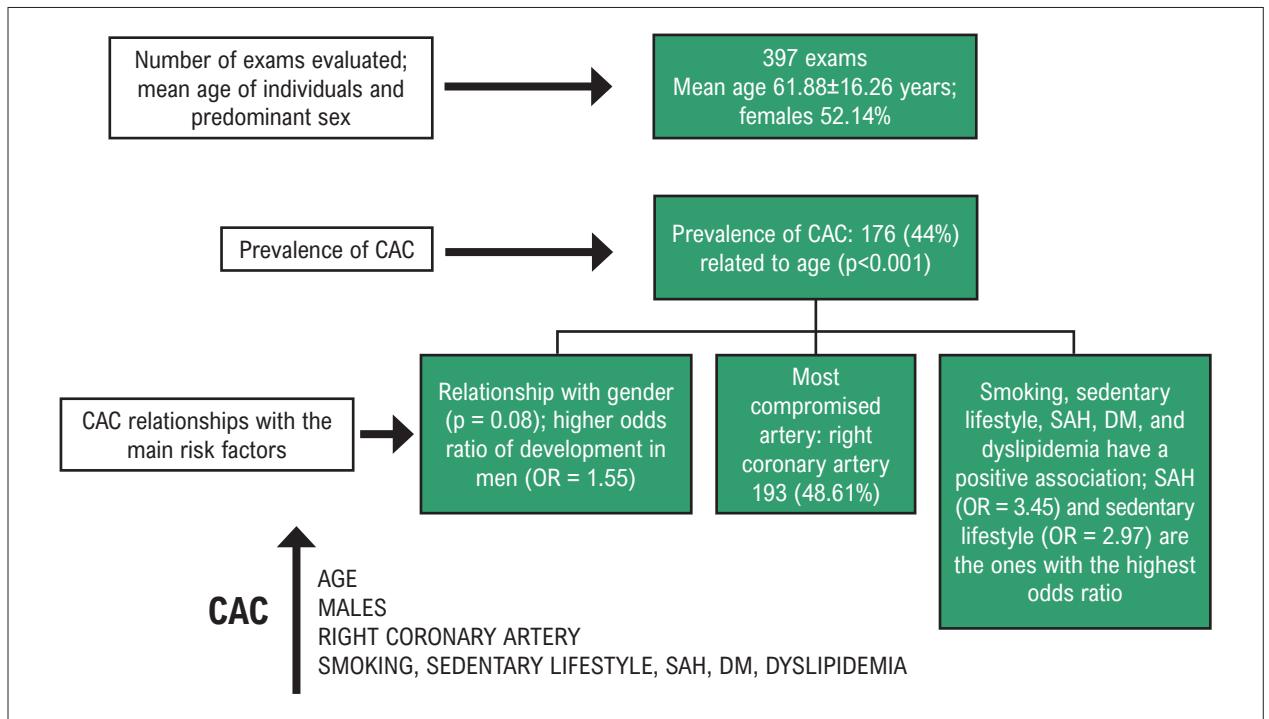


Figure 2 – CAC: coronary artery calcification; DM: diabetes mellitus; SAH: systemic arterial hypertension; OR: odds ratio.

In this line of analysis of coronary arteries, studies^{6,7} with predominantly male population characterization, but similar mean age to our study, found that the prevalence of CAC in asymptomatic individuals is greater than 53%. These data are in line with what was presented in this research, with a predominance of mild and severe calcifications. In the analysis of calcifications in isolation, based on the score, the right coronary artery was shown to be the most compromised, unlike other studies that point to the anterior descending coronary artery.^{12,13} However, this proximal compromise can cause reduction or blockage of the blood flow to a certain area of the myocardium,¹⁴ whose outcome is one

of the main causes of death.¹⁵ This prevalence in asymptomatic patients is important, because when recognized early, helps in prevention, reduces the speed of disease progression, and reduces the associated morbidity and mortality.

Therefore, there are some factors that predispose the appearance of CAC. Among them, the present study found that men are more likely to develop CAC (OR = 1.55), as observed in previous studies;^{5,10} however, there are studies that point out that these findings are independent of gender.⁷ Another point that was proven statistically significant ($p < 0.001$) was the increasing prevalence with growing age. Other studies^{5,7} present data in

line with these findings, which can be explained by the fact that these calcifications occur progressively, as a result of the sum of advancing age and complex biological processes, including genetics, risk factors, diseases acquired throughout life, and environmental factors.¹⁶

Furthermore, the study on the prevalence of CAC in Mexico corroborates what was previously shown and demonstrates that 27% of the participants have CAC, the majority being men (40%), followed by women (13%); both genders were older and had higher values of systolic and diastolic blood pressure, glucose, and LDL cholesterol.¹⁷ In another recent study conducted in northern Brazil, a high prevalence of cardiovascular risk factors associated with coronary calcifications was observed, especially SAH (83.33%), dyslipidemia (62.22%), sedentary lifestyle (74.44%), and overweight (64.44%), being more prevalent in women, who were menopausal in the majority (90.48%).¹⁸ Based on these data, the relevance of this topic can be seen and the relationship between CAC and the variables mentioned is confirmed.

Along these lines, SAH and dyslipidemia, as described in other studies,^{12,19} are statistically significant and have high odds ratios. Studies show that a sedentary lifestyle²⁰ and smoking²¹ have substantial impacts on risk factors, as found in this study. These data are of greater importance when considering that 80% of deaths from CVD could be avoided by quitting smoking habits and practicing physical activity regularly.²²

The present study is a pioneer in the Northwest region of the State of Rio Grande do Sul and has a considerably large sample number for the collection period. However, the limitations of the study include divergences between the observers who analyzed the images, which can be explained by the fact that the exam was not performed with ECG-Gated Cardiac CT (image captured in cardiac diastole), making the analysis difficult; however, they were reassessed, reaching a consensus. The study population showed a selection bias, firstly because the study was carried out in a single hospital and secondly because the individuals included were referred due to clinical indications of different pathologies. The self-applied questionnaire can be considered a weakness, as individuals may omit or not fully understand what is being asked.

Conclusion

The incidental findings of CAC in asymptomatic individuals for heart disease undergoing chest CT showed a prevalence of 44% in the interior of the Northwest of the state of Rio Grande do Sul, Brazil. These vary between mild and severe, with a higher odds ratio in males and an increase in prevalence with age. Therefore, chest CT proves to be an effective method to assess CAC, along

with the patient's clinical history, and can be used to measure risk factors for CVD and intervene in the outcome of the condition.

This study is a pioneer in this region and shows the importance of future investigations, surveys and/or evaluations of patients with CVD.

Acknowledgment

To the Diagnostic Imaging Center of *Hospital Unimed Noroeste*, Rio Grande do Sul, for their availability to carry out the work, to *Universidade Regional do Noroeste do Estado do Rio Grande do Sul* (UNIJUI) for the opportunity to carry out the research, and to the National Council for Scientific and Technological Development (*Conselho Nacional de Desenvolvimento Científico e Tecnológico* – CNPq) for granting scientific initiation scholarships.

Author Contribution

Conception and design of the research: Scopel KRO, Heuser GG, Medeiros TM, Winkelmann ER; writing of the manuscript: Scopel KRO, Medeiros TM, Winkelmann ER; analysis and interpretation of the data: Medeiros TM, Velho MC, Mattod JN, Heuser GG; acquisition of data: Scopel KRO, Maicá BNPM; statistical analysis: Silva MMD; critical revision of the manuscript for intellectual content: Medeiros TM, Heuser GG, Winkelmann ER.

Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

Sources of Funding

There were no external funding sources for this study.

Study Association

This study is not associated with any thesis or dissertation work.

Ethics Approval and Consent to Participate

This study was approved by the Ethics Committee of the *Universidade Regional do Noroeste do Estado do Rio Grande do Sul* under the protocol number 2.739.345 / CAAE: 84431118.2.0000.5350. All the procedures in this study were in accordance with the 1975 Helsinki Declaration, updated in 2013. Informed consent was obtained from all participants included in the study.

References

1. Sociedade Brasileira de Cardiologia. Diretrizes da Sociedade Brasileira de Cardiologia: Pocket Book 2009-2014. Rio de Janeiro: SBC; 2014.
2. Liberman M, Pesaro AEP, Carmo LS, Serrano CV. Calcificação Vascular: Fisiopatologia e Implicações Clínicas. *Einstein*. 2013;11(3):376-82. doi: 10.1590/S1679-45082013000300021.
3. Madhavan MV, Tarigopula M, Mintz GS, Maehara A, Stone GW, Génereux P. Coronary Artery Calcification: Pathogenesis and Prognostic Implications. *J Am Coll Cardiol*. 2014;63(17):1703-14. doi: 10.1016/j.jacc.2014.01.017.
4. Pelandré GL, Sanches NMP, Nacif MS, Marchiori E. Detection of Coronary Artery Calcification with Nontriggered Computed Tomography of the Chest. *Radiol Bras*. 2018;51(1):8-12. doi: 10.1590/0100-3984.2016.0181.
5. Jairam PM, Gondrie MJ, Grobbee DE, Mali WP, Jacobs PC, van der Graaf Y, et al. Incidental Imaging Findings from Routine Chest CT Used to Identify Subjects At High Risk of Future Cardiovascular Events. *Radiology*. 2014;272(3):700-8. doi: 10.1148/radiol.14132211.

6. Sverzellati N, Arcadi T, Salvolini L, Dore R, Zompatori M, Mereu M, et al. Under-Reporting of Cardiovascular Findings on Chest CT. *Radiol Med*. 2016;121(3):190-9. doi: 10.1007/s11547-015-0595-0.
7. Secchi F, Di Leo G, Zanardo M, Ali M, Cannà PM, Sardanelli F. Detection of Incidental Cardiac Findings in Noncardiac Chest Computed Tomography. *Medicine (Baltimore)*. 2017;96(29):e7531. doi: 10.1097/MD.0000000000007531.
8. Sconfienza LM, Mauri G, Muzzupappa C, Poloni A, Bandirali M, Esseridou A, et al. Relevant Incidental Findings at Abdominal Multi-Detector Contrast-Enhanced Computed Tomography: A Collateral Screening? *World J Radiol*. 2015;7(10):350-6. doi: 10.4329/wjr.v7.i10.350.
9. Verdini D, Lee AM, Prabhakar AM, Abbara S, Ghoshhajra B, Writing Group. Detection of Cardiac Incidental Findings on Routine Chest CT: The Impact of Dedicated Training in Cardiac Imaging. *J Am Coll Radiol*. 2018;15(8):1153-7. doi: 10.1016/j.jacr.2016.02.011.
10. Shemesh J, Henschke CI, Shaham D, Yip R, Farooqi AO, Cham MD, et al. Ordinal Scoring of Coronary Artery Calcifications on Low-Dose CT Scans of the Chest is Predictive of Death From Cardiovascular Disease. *Radiology*. 2010;257(2):541-8. doi: 10.1148/radiol.10100383.
11. Landis JR, Koch GG. The Measurement of Observer Agreement for Categorical Data. *Biometrics*. 1977;33(1):159-74.
12. Gabriel FS, Gonçalves LFG, Melo EV, Sousa ACS, Pinto IMF, Santana SMM, et al. Atherosclerotic Plaque in Patients with Zero Calcium Score at Coronary Computed Tomography Angiography. *Arq Bras Cardiol*. 2018;110(5):420-7. doi: 10.5935/abc.20180063.
13. Phillips WJ, Johnson C, Law A, Turek M, Small AR, Inacio JR, et al. Reporting of Coronary Artery Calcification on Chest CT Studies in Breast Cancer Patients at High Risk of Cancer Therapy Related Cardiac Events. *Int J Cardiol Heart Vasc*. 2018;18:12-16. doi: 10.1016/j.ijcha.2018.02.001.
14. Ouchi JD, Teixeira C, Ribeiro CAG, Oliveira CC. Arrival time of Infarcted Patient in the Intensive Care Unit: Importance of Fast Care Services. *Ensaios Cienc Biol Agrar. Saúde*. 2017; 21(2):92-7.
15. Brasil. Ministério da Saúde. Sistema de Informação sobre a Mortalidade. Brasília; Ministério da Saúde; 2013.
16. Shemesh J. Coronary Artery Calcification in Clinical Practice: What We Have Learned and Why Should It Routinely Be Reported On Chest CT? *Ann Transl Med*. 2016;4(8):159. doi: 10.21037/atm.2016.04.08.
17. Posadas-Romero C, López-Bautista F, Rodas-Díaz MA, Posadas-Sánchez R, Kimura-Hayama E, Juárez-Rojas JG, et al. Prevalence and Extent of Coronary Artery Calcification in an Asymptomatic Cardiovascular Mexican Population: Genetics of Atherosclerotic Disease Study. *Arch Cardiol Mex*. 2017;87(4):292-301. doi: 10.1016/j.acmx.2016.12.004.
18. Silveira EL, Cunha LM, Pantoja MS, Lima AVM, Cunha ANA. Risk Factors of Coronary Disease Among Patients Subjected to Myocardial Revascularization (ABG) in Joinville/SC. *Rev Fac Ciênc Méd Sorocaba*. 2018;20(3):172-8. doi: 10.13037/ras.vol18n65.6517.
19. Oliveira JL, Hirata MH, Sousa AG, Gabriel FS, Hirata TD, Tavares Ida S, et al. Male Gender and Arterial Hypertension are Plaque Predictors at Coronary Computed Tomography Angiography. *Arq Bras Cardiol*. 2015;104(5):409-16. doi: 10.5935/abc.20150028.
20. Delaney JA, Jansky NE, Criqui MH, Whitt-Glover MC, Lima JA, Allison MA. The Association Between Physical Activity and Both Incident Coronary Artery Calcification and Ankle Brachial Index Progression: The Multi-Ethnic Study of Atherosclerosis. *Atherosclerosis*. 2013;230(2):278-83. doi: 10.1016/j.atherosclerosis.2013.07.045.
21. Pham T, Fujiyoshi A, Hisamatsu T, Kadowaki S, Kadota A, Zaid M, et al. Smoking Habits and Progression of Coronary and Aortic Artery Calcification: A 5-Year Follow-Up of Community-Dwelling Japanese Men. *Int J Cardiol*. 2020;314:89-94. doi: 10.1016/j.ijcard.2020.05.016.
22. GBD 2017 Disease and Injury Incidence and Prevalence Collaborators. Global, Regional, and National Incidence, Prevalence, and Years Lived with Disability for 354 Diseases and Injuries for 195 Countries and Territories, 1990-2017: A Systematic Analysis for the Global Burden of Disease Study 2017. *Lancet*. 2018;392(10159):1789-1858. doi: 10.1016/S0140-6736(18)32279-7.



This is an open-access article distributed under the terms of the Creative Commons Attribution License