Predicting Coronary Artery Calcium Using Abdominal Aorta and Visceral Artery Calcification

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Introduction

CAC scoring has emerged as a widely available, consistent, and reproducible means of assessing risk for major cardiovascular outcomes, especially useful in asymptomatic people for planning primary prevention interventions such as statins and aspirin.1
The Multiethnic Study of Atherosclerosis (MESA) demonstrated that a CAC score of 0 represents a less than 5 percent 10-year Atherosclerotic cardiovascular disease (ASCVD) risk. CAC scores 1-299 represent borderline to intermediate risk, and CAC score >300 represents a “high risk” 10 percent or greater 10-year ASCVD risk.2
When used correctly, CAC scoring is a powerful predictor of ASCVD risk and holds the key for many patients to receive appropriate and timely treatment for cardiovascular disease. Unfortunately, because testing is recommended only in patients that are asymptomatic for CVD, many of those to whom the screening test would be beneficial never have the test performed.3
This study aims to increase the reach of CAC scoring to a larger population prior to the onset of CVD symptoms by predicting CAC scores using a novel scoring system to grade calcification of the Abdominal Aorta (AA), Celiac (CA), Superior Mesenteric (SMA), and Renal Arteries (RA) discovered incidentally on abdominal non-contrast Computed Tomography imaging. Patients who receive abdominal imaging for kidney stone protocol, abdominal pain, or other reasons may also be screened for ASCVD risk.
In prior studies AA calcification has been well described as predictive of CAC scores4, 5, 6, but to our knowledge no studies have attempted to correlate the AVAC scores with CAC scores. A combination of both scores could be more predictive of CAC than AA scoring alone.

Aims and Objectives

Aim:
This study aims to enhance cardiovascular risk assessment in asymptomatic individuals by evaluating the predictive value of abdominal aortic (AA) and abdominal visceral arterial calcification (AVAC) for coronary artery calcium (CAC) scoring using non-contrast computed tomography (CT) imaging. By establishing a correlation between incidental abdominal vascular calcifications and CAC scores, we seek to expand the clinical utility of non-cardiac CT scans for cardiovascular disease (CVD) risk stratification.

Objectives:

1. **Assess the Predictive Value of AA and AVAC Scoring**
2. **Compare AVAC and AA Scoring for CAC Prediction**
3. **Analyze the Clinical Utility of Incidental Calcification Findings**
4. **Validate Inter-reader Reliability**

By achieving these objectives, this study aims to provide a cost-effective and widely accessible method for identifying patients at increased cardiovascular risk, facilitating early intervention and improved preventive strategies.

Methods

A retrospective chart review was performed of 286 patients who underwent coronary artery calcium scoring within one year of a non-contrast CT of the abdomen and pelvis within the Beaumont Health System between Jan 2018 and Aug 2023. Patients who had a previously diagnosed heart condition or had studies with limited visibility of visceral arteries
were excluded. In total 281 patients were included. A retrospective analysis of non-contrast CT scans of the abdomen and pelvis were reviewed solely for evaluation of calcified atherosclerotic disease of the abdominal aorta as well as visceral arteries including the CA, SMA, RRA and LRA. Analysis and grading were performed by two independent board eligible radiologists.
Atherosclerotic disease of the abdominal aorta was graded on a 0-3 numerical scale as follows - a score of 0 represented no atherosclerotic calcifications, 1 represented scattered atherosclerotic calcifications (<25% vessel circumference involvement), 2 represented near circumferential calcifications (25-75% of the vessel circumference) involving any point along the vessel length, and 3 represented complete atherosclerotic disease completely encircling the vessel (>75% of the vessel circumference) (**figure 1**).

EXAMPLES OF QUALITATIVE SCORING SYSTEMS

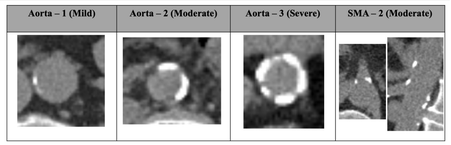

Figure 1 – Examples of atherosclerotic calcifications grading involving abdominal aorta on NECT in the axial plane and proximal superior mesenteric artery (axial and sagittal imaging of SMA provided).

Visceral arteries (celiac, SMA, and bilateral renal arteries) were graded similarly, with special attention paid to the ostia of the vessel from the abdominal aorta. Grading was performed on a 0-3 numerical scale as follows – a score of 0 represented no calcified atherosclerotic disease, 1 represented scattered calcifications within the vessels, 2 represented greater calcifications at the ostia (figure 1), and 3 represented severe atherosclerotic calcifications with significant narrowing of the ostia and extension along the distal aspect of the vessels.
Qualitative scoring was used for sake of description, with a score of 0 = no disease, 1 = mild disease, 2 = moderate disease and 3 = severe disease.
Raw data was compiled for grading of the AA, CA, SMA, RRA, and LRA independently using the qualitative scoring system. Comparative analysis of AA and AVAC scores was performed in relation to independently assigned CAC scores from previous examinations using a pairwise comparison of receiver operating characteristic (ROC) curves. Area under the curve (AUC) was calculated and a Standard Error (SE) and a 95% Confidence interval was established for each variable. Inter-reader reliability analysis was also performed.

Results

A total of 281 non-contrast CT abdomen scans were compared with formal CAC studies taken within the same year. Moderate to severe CVD was defined as CAC >300, with AA scores >2 and any AVAC score used as predictors. Low-risk CVD was defined by a CAC score of 0, with AA = 0 or AVAC = 0 as predictors.

Predicting Moderate to Severe CVD
Among the 281 individuals, 46 (16.37%) had CAC >300, while 235 (83.63%) had CAC = 0. The predictive abilities of AAC >2 and AVASC >1 for CAC >300 were evaluated using ROC curve analysis. The 95% confidence interval for AAC >2 was 0.690–0.795, while AVASC >1 had a 95% CI of 0.723–0.824 (Figure 2).

Pairwise comparison of ROC curves showed a difference in areas of 0.0309 (SE = 0.0385, 95% CI = -0.0445 to 0.106, z statistic = 0.803, P = 0.4217), indicating no significant difference between AAC >2 and AVASC >1 in predicting CAC >300. Both AAC and AVAC were statistically significant predictors, but the difference between their predictive abilities was not significant (Table 1).

Statistical Analysis of Moderate to Severe CVD

Variable	AUC	SE	95% CI
Abdominal Aorta Calcification >2	0.745	0.0372	0.690 to 0.795
Any visceral Artery Calcification >2	0.776	0.0337	0.723 to 0.824

Pairwise comparison of AAC and AVAC ROC curve’s ability to predict CAC>300

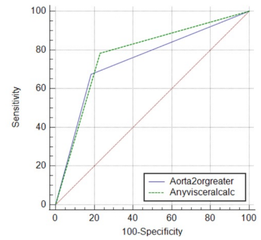

***Figure 2** – ROC curve of AAC >2 (blue) and AVACS >1 (green) ability to predict CAC >300.*

Predicting Low-Risk CVD
For predicting low-risk CVD (CAC = 0), the same cohort of 281 individuals was analyzed. Of these, 102 (36.30%) had CAC >0, while 179 (63.70%) had CAC = 0. The 95% CI for AAC = 0 was 0.593–0.707, while AVASC = 0 had a 95% CI of 0.632–0.743 (Figure 2).

Pairwise ROC curve comparison between AAC = 0 and AVAC = 0 showed a difference of 0.0382 (SE = 0.0316, 95% CI = -0.0237 to 0.100, z statistic = 1.210, P = 0.2263), again indicating no statistically significant difference in predictive abilities (Table 2). Although AVAC had a slightly higher AUC than AAC, this difference was not significant.

Statistical Analysis of Low Risk CVD

Variable	AUC	SE	95% CI
Abdominal Aorta Calcification = 0	0.652	0.0296	0.593 to 0.707
Total Visceral Artery Calcification = 0	0.69	0.023	0.632 to 0.743

***Table 2** - Results following analysis of 281 patients based on the ability to predict CAC=0.*

Pairwise comparison of AAC and AVAC ROC curve’s ability to predict CAC=0

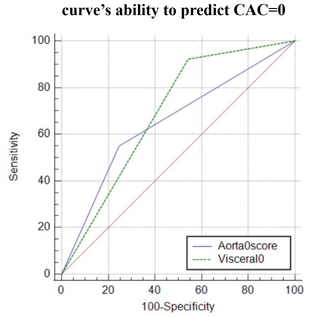

***Figure 2** – ROC curve of AAC =0 (blue) and combined AVACS =0 (green)*

Conclusions

Combined, we have shown that AVAC and AAC are statistically significant predictors of CAC scores in patients who have had non-contrast CT abdomen studies performed incidentally. Using this data, clinicians can reliably consider
starting anti-lipid and anti-platelet therapy for patients who have moderate to severe CVD predicted with a AAC >2 or AVAC>1. Physicians also consider stopping anti-lipid and anti-platelet therapies in patients with a AVAC=0 or AAC=0 as they have a high likelihood of having CAC=0. Using this tool incorporates the benefits of a low-cost non-invasive approach to CVD management while also limiting the potential drawbacks of a dedicated CAC scan by making the test readily available to any patient who has had non-contrast CT imaging done on the abdomen within the past year.

References

1. Greenland P, Blaha MJ, Budoff MJ, Erbel R, Watson KE. Coronary Calcium Score and Cardiovascular Risk. J Am Coll Cardiol. 2018 Jul 24;72(4):434-447. doi: 10.1016/j.jacc.2018.05.027. PMID: 30025580; PMCID: PMC6056023.

2. Budoff MJ, Young R, Burke G, Jeffrey Carr J, Detrano RC, Folsom AR, Kronmal R, Lima JAC, Liu KJ, McClelland RL, Michos E, Post WS, Shea S, Watson KE, Wong ND. Ten-year association of coronary artery calcium with atherosclerotic cardiovascular disease (ASCVD) events: the multi-ethnic study of atherosclerosis (MESA). Eur Heart J. 2018 Jul 1;39(25):2401-2408. doi: 10.1093/eurheartj/ehy217. PMID: 29688297; PMCID: PMC6030975.

3. Bell KJL, White S, Hassan O, Zhu L, Scott AM, Clark J, Glasziou P. Evaluation of the Incremental Value of a Coronary Artery Calcium Score Beyond Traditional Cardiovascular Risk Assessment: A Systematic Review and Meta-analysis. JAMA Intern Med. 2022 Jun 1;182(6):634-642. doi: 10.1001/jamainternmed.2022.1262. Erratum in: JAMA Intern Med. 2022 Aug 1;:null. PMID: 35467692; PMCID: PMC9039826.

4. Horbal SR, Derstine BA, Brown E, Su GL, Wang SC, Holcombe SA. Reference distributions of aortic calcification and association with Framingham risk score. Sci Rep. 2023 Jun 9;13(1):9421. doi: 10.1038/s41598-023-36565-8. PMID: 37296154; PMCID: PMC10256704.

5. Hata Y, Mochizuki J, Okamoto S, Matsumi H, Hashimoto K. Aortic calcification is associated with coronary artery calcification and is a potential surrogate marker for ischemic heart disease risk: A cross-sectional study. Medicine (Baltimore). 2022 Jul 22;101(29):e29875. doi: 10.1097/MD.0000000000029875. PMID: 35866765; PMCID: PMC9302345.

6. Zweig BM, Sheth M, Simpson S, Al-Mallah MH. Association of abdominal aortic calcium with coronary artery calcium and obstructive coronary artery disease: a pilot study. Int J Cardiovasc Imaging. 2012 Feb;28(2):399-404. doi: 10.1007/s10554-011-9818-1. Epub 2011 Feb 24. PMID: 21347596.

7. Tsao, C. W., Aday, A. W., Almarzooq, Z. I., Anderson, C. A. M., Arora, P., Avery, C. L., Baker-Smith, C. M., Beaton, A. Z., Boehme, A. K., Buxton, A. E., Commodore-Mensah, Y., Elkind, M. S. V., Evenson, K. R., Eze-Nliam, C., Fugar, S., Generoso, G., Heard, D. G., Hiremath, S., Ho, J. E., … Martin, S. S. (2023). Heart Disease and Stroke Statistics - 2023 Update: A Report from the American Heart Association. In Circulation (Vol. 147, Issue 8). https://doi.org/10.1161/CIR.0000000000001123

8. Arnett DK, Blumenthal RS, Albert MA, et al. 2019 ACC/AHA Guideline on the Primary Prevention of Cardiovascular Disease: A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines [published correction appears in Circulation. 2019 Sep 10;140(11):e649-e650] [published correction appears in Circulation. 2020 Jan 28;141(4):e60] [published correction appears in Circulation. 2020 Apr 21;141(16):e774]. Circulation. 2019;140(11):e596-e646. doi:10.1161/CIR.0000000000000678

9. Suzuki Y, Matsumoto N, Yoda S, Amano Y, Okumura Y. Coronary artery calcium score: Current status of clinical application and how to handle the results. J Cardiol. 2022;79(5):567-571. doi:10.1016/j.jjcc.2021.11.020

10. Rozanski A, Gransar H, Shaw LJ, et al. Impact of coronary artery calcium scanning on coronary risk factors and downstream testing the EISNER (Early Identification of Subclinical Atherosclerosis by Noninvasive Imaging Research) prospective randomized trial. J Am Coll Cardiol. 2011;57(15):1622-1632. doi:10.1016/j.jacc.2011.01.019

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