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Original Research

# Prevalence of thoracic aortic aneurysm in patients referred for no/low-charge coronary artery calcium scoring: Insights from the CLARIFY registry

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ABSTRACT

*Objective:* Low-dose cardiac-gated chest CTs allow for simultaneous evaluation of coronary artery calcification and aortic size. We sought to evaluate the prevalence of thoracic aortic dilation (TAD) and thoracic aortic aneurysm (TAA) in a large cohort of patients undergoing coronary artery calcium (CAC) screening.

*Methods:* We reviewed all patients from a large, prospective no-charge CAC screening program (CLARIFY, Clinicaltrials.gov NCT04075162) for whom measurements of the ascending aorta were available. TAD was defined as an ascending aortic diameter ≥4.0cm, while TAA was defined as ascending aortic diameter ≥ 4.5cm. We explored associations between patient characteristics, CAC, and the prevalence of TAD/TAA.

*Results:* A total of 36,356 patients enrolled in the CLARIFY program underwent analysis for TAD/TAA. 3,130 patients (8.6%) had TAD and 237 (0.7%) had TAA. Patients with TAA were older (63±8 vs 59±10 years, $p < 0.001$), more likely to be male (87% vs 49%, $p < 0.001$), have higher BMI (32 vs 30 kg/m$^2$, $p < 0.001$), and 10-year atherosclerotic cardiovascular disease estimated risk (18% vs 12%, $p < 0.001$). Similar differences were observed for individuals with TAD compared to individuals without TAD with respect to age (63 vs 59 years, $p < 0.001$), percent male (76% vs 46%, $p < 0.001$), BMI (32 vs 30 kg/m$^2$, $p < 0.001$), and 10-year predicted risk (17% vs 11%, $p < 0.001$). CAC score was associated with prevalence of TAD (4.9% in those with CAC 0 to 16.5% in those with CAC≥400) and TAA (0.3% in those with CAC of 0 to 1.5% in those with CAC ≥400).

*Conclusion:* In this large, prospective study of patients undergoing no-charge CAC screening, 8.6% had TAD (≥4.0cm) and 0.7% had TAA (≥4.5cm). Our results highlight a high yield of TAD/TAA diagnosis in this targeted cohort with cardiovascular risk factors and supports the role of no-charge CAC as a population-level strategy.

## 1. Background

Thoracic aortic dilation (TAD) and thoracic ascending aortic aneurysms (TAA) are frequently found incidentally on thoracic imaging. TAAs are defined as a permanent, localized, arterial dilations of all 3 layers of the aortic wall greater than 50% larger than the diameter of the contiguous portion of the aorta [1]. TAAs are considered "silent killers" due to their asymptomatic nature, yet high mortality associated with dissection and rupture [2].

Despite over 250 years since the first publication of Frank Nicholl's observation of King George II's death due to acute thoracic aortic pathology [3], the mortality from ruptured thoracic aortic aneurysm (TAA)

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has not seen the same decline as other aortic pathologies [2]. This may in part be due to TAA's less defined demographics and epidemiology, that is in contrast to abdominal aortic aneurysms (AAA), which carry a lower mortality rate and have been well studied and described in robust population-based cohorts [4]. Similarly, unlike AAA, no recommendations currently exist for population-level screening of TAA. Coronary artery calcium (CAC) scoring, performed on non-contrast low-dose gated thoracic CT scans, offers an opportunity to screen for TAD/TAA. We sought to investigate the utility of wide-spread no-charge coronary artery calcium scoring for the identification of TAD/TAA in a higher-than-average risk population.

## 2. Methods

University Hospitals Health System (UHHS) is one of Northern Ohio's largest healthcare systems, comprising over 30 Health Centers [5]. In 2014, a system-wide computed tomography (CT) CAC program available at low-charge ($99 per test) was started, followed by a no charge CAC program in January 2017. The cost of offering no/low charge CAC screening was offset by scheduling patients in CT scanners across the entire health system (18 total CT scanners) when the CT scanners were not being utilized for other studies, thereby enhancing efficiency for a fixed cost (maintenance and upkeep of CT scanners and personnel time).

CAC scoring was offered to all males aged 45 years or older and females aged 55 years or older with no history of cardiovascular disease and in individuals who had one or more risk factors for heart disease, including: dyslipidemia, hypertension, smoking, diabetes mellitus (DM), family history of coronary artery disease (at age 55 or younger in men and 65 or younger in women). The scan was also made available for men and women aged 40 or older diagnosed with a chronic inflammatory condition (e.g., inflammatory bowel disease, systemic lupus erythematosus, rheumatoid arthritis, ankylosing spondylitis, and psoriasis). We included all patients who were referred to the CAC program at UHHS from January 1st, 2014, to November 4th, 2020. Patient data were captured using electronic medical records and were maintained in a prospective registry, the Community Calcium Scoring Assessment for Cardiovascular Risk Stratification (CLARIFY, ClinicalTrials.gov NCT04075162). This study was approved by the Institutional Review Board at University Hospitals.

Thoracic aorta diameter was assessed using standardized protocols with Multi-Detector CT (MDCT) scanners with either 64 or 256 rows of detectors. Image acquisition and analysis were standardized across the system and followed protocols recommended by the Society for Cardiovascular Computed Tomography (SCCT) [6]. Subjects were positioned within the gantry of the MDCT scanner in supine position. During a single breath hold, images of the heart, from the level of the tracheal bifurcation to below the base of the heart, were acquired using prospective electrocardiographic triggering at 50–80% of the RR-interval, depending on the heart rate. The scan parameters were: 16 $\times$ 1.5 mm collimation, 205 mm field of view (FOV), slice thickness of 2.5 mm with interval of 1mm, variable rotation time (scanner specific), 120 kVp and 40–60 mAs (based on body mass index). Every scan procured throughout the healthcare system was sent to a centralized reading facility for analysis, including the assessment of CAC score and thoracic aortic diameter. University Hospitals follows the multi-societal recommendations for CT measurement of the thoracic aortic diameter, which involves the double oblique view and measurement of the aortic wall. Given the non-contrast nature of the scans, this allows for reproducibility between readers [7,8].

We explored the difference in patient demographics and characteristics, CAC results, and metabolic health parameters in patients with and without TAD or TAA. Demographic data and patient histories were extracted from the electronic medical record system at UHHS. Race was self-reported. The timing of reported laboratory values (low density lipoprotein [LDL], total cholesterol, high density lipoprotein [HDL], triglycerides, hemoglobin A1c) refer to the most recent value within 365 days prior to CT image acquisition and up to 1 month post CT image acquisition. For analyses of medication prescription, the denominator was all patients who had at least one documented physician visit in the electronic medical record prior to CT image acquisition. Atherosclerotic cardiovascular disease risk was estimated using the American College of Cardiology/American Heart Association Pooled Cohort Equations Risk Model (PCE) [9].

Categorical variables are presented as the number of individuals and overall percentages, while continuous variables are presented as a mean with standard deviation or median with 25th−75th percentiles. TAD was defined as an aortic diameter $\geq$4.0 cm and TAA was defined as an aortic diameter $\geq$4.5cm [10]. Comparisons were done using chi square (for categorical variables), ANOVA (for normally distributed continuous variables), and the Mann-Whitney U test (for non-normally-distributed continuous variables) as appropriate. These analyses included only patients who had baseline and follow-up values of metabolic health parameters. We additionally performed multivariable logistic regression to identify factors associated with TAD/TAA. For these models, we selected variables that are risk factors or surrogates of risk factors for TAD/TAA (CAC score, age, sex, race, systolic blood pressure [SBP], diastolic blood pressure [DBP], body mass index [BMI], diabetes mellitus [DM], antihypertensive use, statin use, tobacco use, autoimmune disease [rheumatoid arthritis, lupus, inflammatory bowel disease]). We provide adjusted odds ratio and 95% confidence interval from logistic regression for TAD and TAA. Statistical Package for Social Sciences version 21 (IBM, NY) was used for analyses. Two-sided $p < 0.05$ was considered statistically significant.

## 3. Results

A total of 36,356 patients enrolled in the CLARIFY program underwent analysis for TAD/TAA. The mean effective dose was 0.89 $\pm$ 0.29 mSV (acquired from a random sample of 100 scans). Overall, 3,130 patients (8.6%) were found to have TAD. Patients with TAD were older and more likely to be male in comparison to those without TAD. In those with TAD, 175 patients (5.6%) were black, 2840 patients (90.7%) were white, 46 patients (1.5%) were of other races, and the remaining 69 patients (2.2%) were of unknown race. Mean body mass index (BMI) was greater in those with TAD than those without. The prevalence of hypertension (HTN), mean SBP, and mean DBP were all greater in those with TAD than those without TAD. Statin use was more common in the TAD group. Total cholesterol, HDL, and LDL were all lower in those with TAD than those without TAD. Tobacco use was more common in those with TAD than those without TAD, as was aspirin use. Estimated 10-year risk of major adverse cardiovascular events via the PCE was greater in those with TAD than those without. There were no differences in mean hemoglobin A1c, the prevalence of DM, or median household income among those with TAD vs those without TAD. These results are presented in Table 1.

Overall, 237 patients (0.7%) were found to have TAA. Patients with TAA were older and more commonly male in comparison to those without TAA. In those with TAA, 13 patients (5.5%) were black, 215 patients (90.7%) were white, 3 patients (1.3%) were of other races, and the remaining 6 patients (2.5%) were of unknown race. Mean BMI was greater in those with TAA than those without. The prevalence of HTN, mean SBP, and mean DBP were all greater in those with TAA than those without TAA. Statin use was more common in the TAA group. Total cholesterol, HDL, and LDL were all lower in those with TAA than those without TAA. Estimated 10-year risk of MACE via the PCE was greater in those with TAA than those without. There were no differences in the prevalence of DM, mean hemoglobin A1c, tobacco use, aspirin use, or median household income among those with TAA vs those without TAA. These results are presented in Table 2.

The prevalence of TAD and TAA significantly increased with CAC, both overall and when stratified by sex (Fig. 1). A similar analysis was

**Tables 1**
Demographics and characteristics of individuals with thoracic aortic dilation (TAD).

| Characteristic | No Dilation | TAD | *p*-value |
|---|---|---|---|
| Patients (n) | 33226 (91.4%) | 3130 (8.6%) | |
| Age (years) | 59.1±9.6 | 63.2±8.1 | <0.001 |
| Gender (n) | | | <0.001 |
| Female | 17888 (53.8%) | 747 (23.9%) | |
| Male | 15338 (46.2%) | 2383 (76.1%) | |
| Race (n) | | | <0.001 |
| Black | 2867 (8.6%) | 175 (5.6%) | |
| White | 28749 (86.5%) | 2840 (90.7%) | |
| Other | 695 (2.1%) | 46 (1.5%) | |
| Unknown | 915 (2.8%) | 69 (2.2%) | |
| Median Household Income ($10,000) | 6.8±2.2 | 6.9±2.1 | 0.532 |
| Vitals | | | |
| BMI (Kg/m$^2$) | 29.9±6.4 | 31.6±6.5 | <0.001 |
| Systolic Blood Pressure (mmHg) | 129.3±16.1 | 133.1±16.1 | <0.001 |
| Diastolic Blood Pressure (mmHg) | 78±9.6 | 80.6±9.7 | <0.001 |
| Medical History (n, %) | | | |
| Hypertension | 9455 (28.5%) | 1225 (39.1%) | <0.001 |
| Diabetes | 4220 (12.7%) | 415 (13.3%) | 0.193 |
| Tobacco Use | 7139 (21.5%) | 787 (25.2%) | <0.001 |
| Aspirin Use | 7364 (22.2%) | 878 (28.1%) | <0.001 |
| Statin Use | 10757 (32.4%) | 1150 (36.7%) | <0.001 |
| Pooled Cohort Equation 10-year Risk (%) | 11.3±10.5 | 16.9±11.5 | <0.001 |
| Laboratory Values | | | |
| Mean Hemoglobin A1c (%) | 6.2±1.4 | 6.2±1.4 | 0.9 |
| Total Cholesterol (mg/dL) | 203.2±44.5 | 192±43.3 | <0.001 |
| HDL (mg/dL) | 54.3±16.1 | 50.5±14.5 | <0.001 |
| LDL (mg/dL) | 122.4±38.4 | 115±36.9 | <0.001 |
| Triglycerides (mg/dL) | 135.1±97.4 | 135.6±85.1 | 0.852 |
| CT Scan Variables | | | |
| CAC (Agatston Units) | | | <0.001 |
| 0 | 14330 (43.1%) | 733 (23.4%) | |
| 1-99 | 10079 (30.3%) | 939 (30%) | |
| 100-399 | 5124 (15.4%) | 724 (23.2%) | |
| ≥400 | 3691 (11.1%) | 731 (23.4%) | |

Continuous variables shown with mean ± standard deviation. BMI (Body mass index), HDL (high density lipoprotein), LDL (low density lipoprotein), CAC (Coronary artery calcium score).

**Table 2**
Demographics and characteristics of individuals with thoracic aortic aneurysm (TAA).

| Characteristic | No Aneurysm | TAA | *p*-value |
|---|---|---|---|
| Patients (n) | 36119 (99.3%) | 237 (0.7%) | |
| Age (years) | 59.4±9.6 | 63.2±8.3 | <0.001 |
| Gender (n) | | | <0.001 |
| Female | 18604 (51.5%) | 31 (13.1%) | |
| Male | 17515 (48.5%) | 206 (86.9%) | |
| Race (n, %) | | | 0.321 |
| Black | 3029 (8.4%) | 13 (5.5%) | |
| White | 31374 (86.9%) | 215 (90.7%) | |
| Other | 738 (2.0%) | 3 (1.3%) | |
| Unknown | 978 (2.7%) | 6 (2.5%) | |
| Median Household Income (1/ $10,000) | 6.8±2.2 | 7.1±2.3 | 0.095 |
| Vitals | | | |
| BMI (Kg/m2) | 30.1±6.4 | 32.3±6.3 | <0.001 |
| Systolic Blood Pressure (mmHg) | 129.6±16.1 | 134.5±14.4 | <0.001 |
| Diastolic Blood Pressure (mmHg) | 78.2±9.6 | 80.8±10.0 | 0.001 |
| Medical History (n, %) | | | |
| Hypertension | 10589 (29.3%) | 91 (38.4%) | 0.003 |
| Diabetes | 4606 (12.8%) | 29 (12.2%) | 0.913 |
| Tobacco Use | 7865 (21.8%) | 61 (25.7%) | 0.153 |
| Aspirin Use | 8176 (22.6%) | 66 (27.8%) | 0.059 |
| Statin Use | 11824 (32.7%) | 83 (35.0%) | 0.447 |
| Pooled Cohort Equation 10-year Risk (%) | 11.7±10.7 | 18.3±11.7 | <0.001 |
| Laboratory Values | | | |
| Hemoglobin A1c (%) | 6.2±1.4 | 6.2±1.2 | 0.96 |
| Total Cholesterol (mg/dL) | 202.3±44.5 | 189.2±47.3 | 0.002 |
| HDL (mg/dL) | 54±16.0 | 50.3±15.2 | 0.014 |
| LDL (mg/dL) | 121.8±38.3 | 113.8±39.1 | 0.029 |
| Triglycerides (mg/dL) | 135.1±96.5 | 132.3±89.0 | 0.752 |
| CT Variables | | | |
| CAC (Agatston Units) | | | <0.001 |
| 0 | 15014 (41.6%) | 49 (20.8%) | |
| 1-99 | 10950 (30.3%) | 68 (28.8%) | |
| 100-399 | 5797 (16.1%) | 51 (21.6%) | |
| ≥400 | 4354 (12.1%) | 68 (28.8%) | |

Continuous variables shown with mean ± standard deviation. BMI (Body mass index), HDL (high density lipoprotein), LDL (low density lipoprotein), CAC (Coronary artery calcium score).

performed for each 10-year ASCVD risk group defined by PCE. When examined by group, individuals in the ASCVD group of >20% had a statistically significant higher prevalence of TAD compared to individuals in the <7.5% and 7.5−20% groups (Fig. 2**a**). When exploring the prevalence of TAA, individuals in the ASCVD group of >20% had a significantly higher prevalence of TAA, compared to the 7.5−20% and <7.5% groups (Fig. 2**b**).

In multivariable logistic regression models (Table 3), factors associated with TAD included CAC score, age, male sex, white race, lower SBP, higher DBP, BMI, and antihypertensive use. Factors associated with TAA included age, male sex, body mass index, and antihypertensive use.

In a receiver operating characteristic analysis comparing PCE vs CAC score for the prediction of TAA/TAD, PCE had higher area under the curve compared with CAC score for TAD. PCE performed only marginally better than calcium score for TAA (**Supplemental Fig. 1**).

## 4. Discussion

In this large, prospective, observational study of >36,000 patients being referred for low/no-charge CAC scoring, 8.6% had TAD and 0.7% had TAA. While CAC score has consistently been associated with major adverse cardiovascular events (11), we now demonstrate that CAC score is also modestly associated with the prevalence of TAD/TAA. Additionally, CT image acquisition for CAC scoring has relatively high yield for the diagnosis of TAD/TAA, highlighting an added benefit of CAC scoring in appropriate individuals. Furthermore, using baseline demographic variables and logistic regression, we demonstrated specific variables highly correlated with the prevalence of TAD/TAA (i.e., age, sex, etc.).

This study highlights the benefit of large-scale CAC scoring in relation to non-coronary pathologies. The number of patients identified by CAC screening to have TAD is relatively large and would likely result in improved long-term outcomes for a subset of these patients at risk for acute aortic pathologies via risk factor control and enhanced surveillance. This is suggested by a reduction in several risk factors for both ASCVD (LDL-C, total cholesterol) and TAD/TAA (blood pressure) on follow-up. Our results demonstrate overlap in traditional risk factors for atherosclerotic cardiovascular disease and TAD/TAA. In particular, this is highlighted by the significantly higher 10-year ASCVD risk as estimated by the PCE in those with TAD/TAA and by the good performance of ASCVD risk equations to predict TAA/TAD. Given the strong association between TAD/TAA and PCE, patients selected for CAC scoring

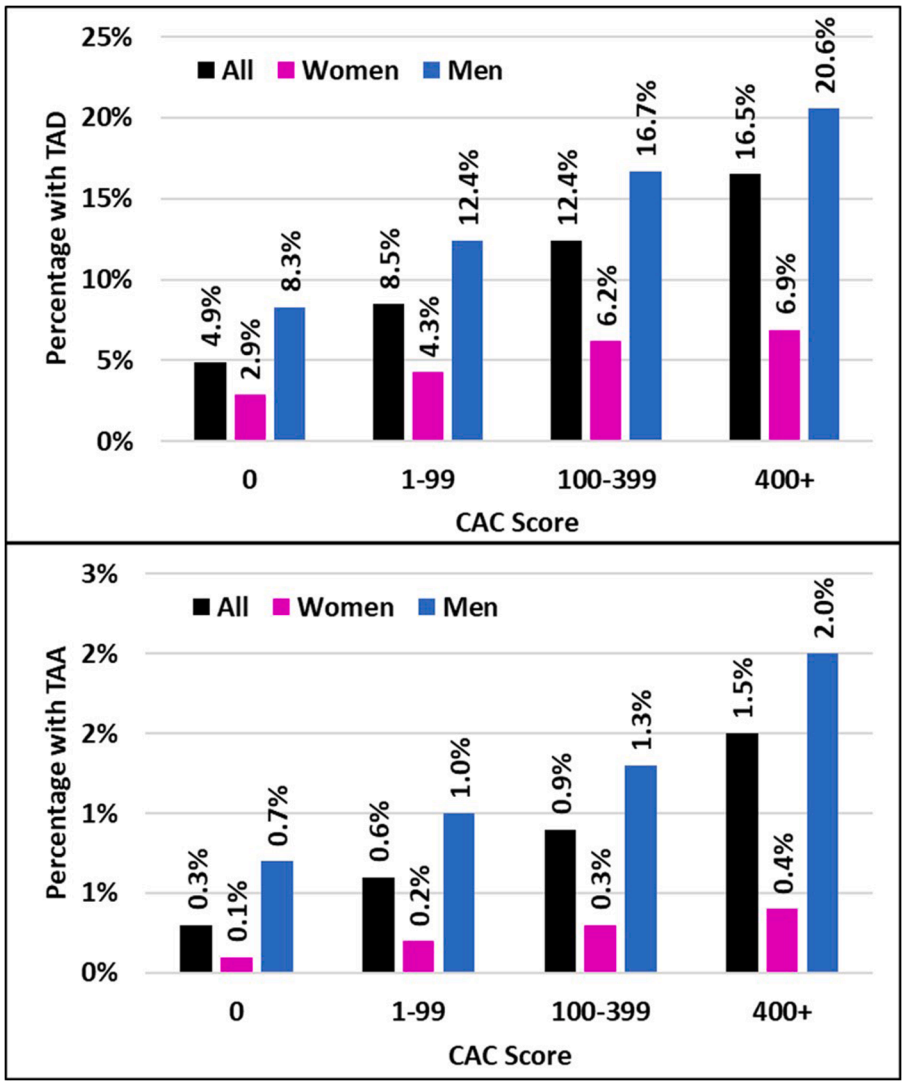


**Fig. 1. Central Illustration**: Prevalence of TAD and TAA by CAC score group and sex. TAD = thoracic aortic dilation; TAA = thoracic aortic dilation; CAC = coronary artery calcium.

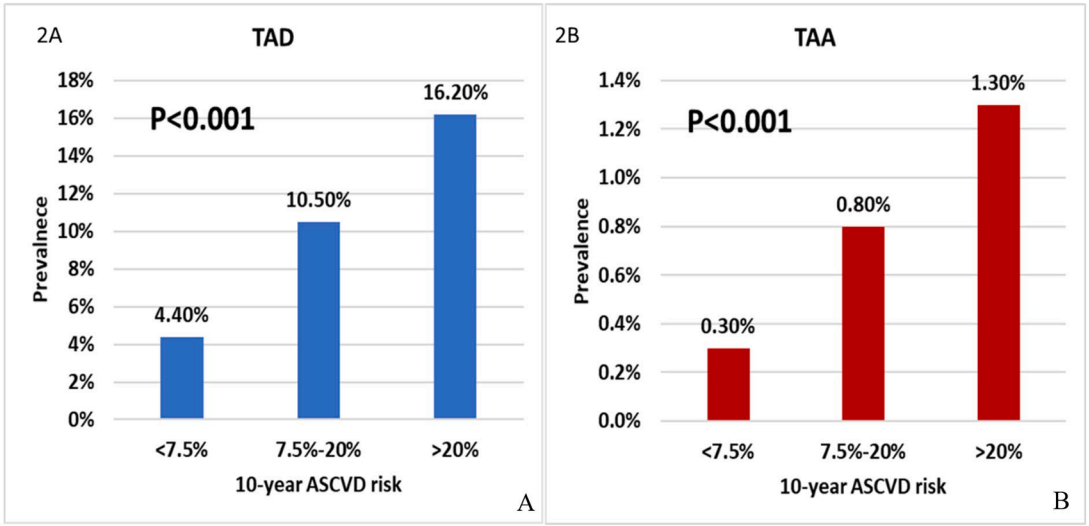


**Fig. 2.** Prevalence of TAD and TAA by AHA/ACC PCE risk group. TAD = thoracic aortic dilation; TAA = thoracic aortic dilation; ASCVD = atherosclerotic cardiovascular disease.

**Table 3**
Logistic Regression of clinical variables predictive of TAD/TAA.

| Variable | TAD<br>**OR [95% CI], *p*-value** | TAA<br>**OR [95% CI], *p*-value** |
|---|---|---|
| CAC 1-99 vs CAC 0 | 1.14 [1.01 - 1.30], $p = 0.041$ | 1.15 [0.73 - 1.81], $p = 0.558$ |
| CAC 100-399 vs CAC 0 | 1.30 [1.12 - 1.50], $p < 0.001$ | 1.04 [0.61 - 1.76], $p = 0.885$ |
| CAC $\geq$ 400 vs CAS 0 | 1.38 [1.18 - 1.61], $p < 0.001$ | 1.44 [0.85 - 2.44], $p = 0.175$ |
| Age, per year | 1.07 [1.06 - 1.07], $p < 0.001$ | 1.06 [1.04 - 1.08], $p < 0.001$ |
| Female vs Male | 0.27 [0.24 - 0.30], $p < 0.001$ | 0.15 [0.10 - 0.24], $p < 0.001$ |
| Race: Black vs White | 0.60 [0.50 - 0.72], $p < 0.001$ | 0.66 [0.35 - 1.24], $p = 0.199$ |
| Race: Other vs White | 0.82 [0.56 - 1.21], $p = 0.318$ | 1.21 [0.38 - 3.84], $p = 0.748$ |
| Race: Unknown vs White | 0.86 [0.58 - 1.26], $p = 0.43$ | 0.76 [0.19 - 3.12], $p = 0.706$ |
| Systolic BP (per 10 mmHg) | 0.95 [0.91 - 0.98], $p = 0.003$ | 1.01 [0.90 - 1.14], $p = 0.831$ |
| Diastolic BP (per 10 mmHg) | 1.36 [1.28 - 1.44], $p < 0.001$ | 1.21 [0.99 - 1.48], $p = 0.069$ |
| Body mass index (per 1 kg/m2) | 1.05 [1.05 - 1.06], $p < 0.001$ | 1.06 [1.04 - 1.09], $p < 0.001$ |
| Diabetes | 0.75 [0.66 - 0.86], $p < 0.001$ | 0.61 [0.39 - 0.97], $p = 0.037$ |
| Antihypertensives | 1.29 [1.17 - 1.43], $p < 0.001$ | 1.48 [1.04 - 2.11], $p = 0.03$ |
| Statins | 0.88 [0.79 - 0.97], $p = 0.009$ | 0.77 [0.55 - 1.08], $p = 0.129$ |
| Smoking | 1.08 [0.97 - 1.19], $p = 0.163$ | 1.12 [0.79 - 1.56], $p = 0.53$ |
| Autoimmune disease | 1.11 [0.86 - 1.42], $p = 0.42$ | N/A, $p = 0.989$ |

DBP (diastolic blood pressure), SBP (systolic blood pressure), BMI (body mass index), Diabetes (Diabetes Mellitus), TAD (Thoracic aortic dilation), TAA (thoracic aortic aneurysm).

based on the American College of Cardiology/American Heart Association (ACC/AHA) guidelines are also likely to benefit from the potential discovery of TAD/TAA [12].

In contrast to our finding of the association between CAC score and TAD/TAA, a prior study investigating this association noted an association between CAC score and AAA, but not TAA [13]. While TAA calcification has been associated with morbidity and mortality [14], the association between CAC score and TAA morbidity and mortality has not been explored. The totality of evidence suggests that TAA is independently associated with all-cause mortality, cardiovascular mortality, and non-fatal cardiovascular events [15]. The pathogenesis of TAA is thought to result from cystic medial degeneration of the aorta, in contrast to AAA, which is thought to be driven by atherosclerosis [16]. This difference in pathogenesis has been invoked to explain the results presented by Cho et al. [13]. Despite difference in pathogenesis, hypertension and aging are known to mediate the cystic medial degeneration responsible for TAD/TAA and atherosclerosis [16]. This overlap in pathogenesis may help to explain the association we have demonstrated between CAC score/PCE and TAD/TAA.

A systematic review and meta-analysis of 22 population-based studies by Gouveia et al. identified 104,519 TAAs with an overall prevalence of 0.16% [17]. However, autopsy-based studies yielded a significantly higher prevalence of 0.76% [17]. Interestingly, our results demonstrate a prevalence (0.7%) that is almost identical to autopsy-based studies, consistent with our higher-than-average risk population. In our study, patients with TAD/TAA were older, more likely to be male, and had higher BMI, 10-year ASCVD risk, prevalence of HTN, and statin use.

When compared with the incidence of ruptured AAA, the incidence of ruptured TAA has not seen the same degree of reduction [2]. In contrast, there has been a sizable improvement in survival in patients with known TAA, which was shown to have increased from 19% between 1951 to 1980 to 56% between 1980 to 1994 in one study [18]. Taken together this data suggests that although the management of TAA is improving, as demonstrated by improved survival, the discrepancy in the incidence of rupture improvement between TAA and AAA may be related to detection. Thus, at an individual level we hope that the utilization of combined CAC and TAA screening to detect thoracic aortic pathology will allow for early and aggressive risk factor modification as recommended by the AHA/ACC Guidelines, with a focus on antihypertensive therapy, particularly beta-adrenergic blockade and angiotensin converting enzyme (ACE) inhibition(8). The benefit of blood pressure control is supported by our data, which shows a higher SBP and DBP in patients with TAD/TAA. Furthermore, we have demonstrated that both SBP and DBP are above the goal recommended by guidelines in patients with TAD/TAA. Follow-up data demonstrates that after TAD/TAA identification, there are significant reductions in DBP and a trend towards significance in reduction of SBP. Following TAD/TAA identification, it is important to consider the presence of a genetic or familial disorders. AHA/ACC guidelines recommend the sequencing of known culprit genes (*TGFBR1, TGFBR2, MYH11*, etc.) in patients deemed to have clinical features of such conditions, followed by counseling and genetic testing in first-degree relatives if appropriate [8].

We hope at an epidemiologic level, our study provides a sample of the potential prevalence of TAA in a population at higher-than-average risk for CAD. This may inspire future research to continue to identify, address, and update screening guidelines [4]. Lastly, at a population level, our study identifies important subgroup and demographic variables associated with TAAs that will encourage future studies to identify at-risk populations who would benefit from early screening with CAC scoring.

There are a few limitations of our study, including the limited ability to generalize our results to the general population. Given our cohort constitutes patients undergoing CAC scoring for cardiovascular risk stratification, this population is at higher risk for cardiovascular disease than the general population, and therefore likely has a higher prevalence of TAD/TAA. Furthermore, these patients expressed interest in a screening CAC score, which indicates a potential greater degree of interest in personal health. Other limitations include the possibility of variability in aortic diameter measurement technique and the predominance of whites and males. Despite these few limitations, we present, to our knowledge, the largest prospective study examining the prevalence of and risk factors for TAD/TAA. An important limitation in both the diagnosis and monitoring of TAA is the error that has been demonstrated in the measurement of aortic diameter. For accurate serial assessment of aortic diameter, follow-up imaging must capture exactly the same anatomic landmark as previous assessments [19]. Furthermore, correct alignment of multiplanar reconstruction orthograde to the aortic centerline must be achieved [19]. Inter-reader variability likely results from the above processes in addition to others. The use of artificial intelligence programs can reduce reporting time and inter-reader variability, with reductions of 63% and 42.5% respectively in one study [19].

## 5. Conclusion

In this large, prospective, observational study of >36,000 patients undergoing CAC screening, 8.6% had TAD and 0.7% had TAA. Our results highlight a substantially higher prevalence of TAA than what has been previously described in meta-analyses, which is consistent with the higher-than-average risk carried by our study population. We hope our research inspires and encourages future efforts at identification of at-risk individuals and updates in screening guidelines for TAA with greater emphasis placed on the utility of CAC scoring.

## Disclosures

None of the authors have conflicts of interest pertinent to this manuscript.

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Tasveer Khawaja, Scott E Janus, Sadeer G. Al-Kindi, and Sanjay Rajagopalan wrote the paper.

Tasveer Khawaja, Nour Tashtish, and Sadeer G. Al-Kindi conducted the analysis.

Nour Tashtish, Matthew Janko, Cristian Baeza, Robert Gilkeson, Sadeer G. Al-Kindi, and Sanjay Rajagopalan provided final review.

**Supplemental Fig. 1A/1B**: ROC Analysis of PCE equation compared to calcium score, TAD (thoracic aortic dilation), TAA (thoracic aortic aneurysm), PCE (American College of Cardiology/American Heart Association Pooled Cohort Equations Risk Model)

## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.ajpc.2022.100378.

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