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Original article

Association Between Thoracic Aorta Calcium and Thoracic Aorta Geometry in a Cohort of Asymptomatic Participants at Increased Cardiovascular Risk

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ABSTRACT

Introduction and objectives: Thoracic aorta calcium detection is known to improve cardiovascular risk prediction for cardiac and noncardiac events beyond traditional risk factors. We investigated the influence of thoracic aorta morphometry on the presence and extent of aortic calcifications.

Methods: Nonenhanced computed tomography heart scans were performed in 970 asymptomatic participants at increased cardiovascular risk. An automated algorithm estimated the geometry of the entire thoracic aorta and quantified the aortic calcium Agatston score. A nonparametric model was used to analyze the percentiles of calcium score by age. Logistic regression models were calculated to identify anatomical associations with calcium levels.

Results: Calcifications were concentrated in the aortic arch and descending portions. Higher amounts of calcium were associated with an enlarged, unfolded, less tapered and more tortuous aorta. The size of the ascending aorta was not correlated with aortic calcium score, whereas enlargement of the descending aorta had the strongest association: the risk of having a global calcium score > 90th percentile was 3.62 times higher (confidence interval, 2.30-5.91; $P < .001$) for each 2.5-mm increase in descending aorta diameter. Vessel taper, tortuosity, unfolding and aortic arch and descending volumes were also correlated with higher amounts of calcium.

Conclusions: Thoracic aorta calcium was predominantly found at the arch and descending aorta and was positively associated with the size of the descending aorta and the aortic arch, but not with the size of the ascending aorta. These findings suggest that aortic dilatation may have different mechanisms and may consequently require different preventive strategies according to the considered segments.

Asociación entre el calcio de la aorta torácica y la geometría de esta en una cohorte de sujetos asintomáticos con riesgo cardiovascular aumentado

Palabras clave:
Aorta
Ateroesclerosis
Calcio
Tomografía computarizada

RESUMEN

Introducción y objetivos: La detección del calcio de la aorta torácica mejora la predicción del riesgo cardiovascular, en cuanto a los eventos cardiacos y no cardiacos, respecto a la obtenida solo con los factores de riesgo tradicionales. En este trabajo se ha investigado la influencia de la morfometría de la aorta torácica en la presencia y la magnitud de las calcificaciones aórticas.

Métodos: Se realizaron exploraciones por tomografía computarizada cardiaca sin contraste en 970 participantes asintomáticos con riesgo cardiovascular aumentado. Se utilizó un algoritmo automático para estimar la geometría de toda la aorta torácica y se cuantificó la puntuación de Agatston del calcio aórtico. Se utilizó un modelo no paramétrico para analizar los percentiles de la puntuación de calcio según la edad. Se calcularon modelos de regresión logística para identificar asociaciones anatómicas con las concentraciones de calcio.

Resultados: Las calcificaciones se concentraron en el cayado aórtico y la aorta descendente. Las mayores cantidades de calcio se asociaron con una aorta agrandada, desplegada, con menor estrechamiento y más

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tortuosa. El tamaño de la aorta ascendente no mostró correlación con la puntuación de calcio de la aorta, mientras que el tamaño de la aorta descendente es el parámetro que mostró mayor asociación: el riesgo de tener una puntuación de calcio global superior al percentil 90 fue 3,62 veces (intervalo de confianza, 2,30-5,91; p < 0,001) mayor por cada 2,5 mm de aumento del diámetro de la aorta descendente. La reducción gradual del diámetro, la tortuosidad, el despliegue y los volúmenes del cayado aórtico y la aorta descendente estaban correlacionados con mayor cantidad de calcio.

Conclusiones: Las calcificaciones se hallaron predominantemente en el cayado aórtico y la aorta descendente y mostraron asociación positiva con el tamaño de la aorta descendente y el cayado aórtico, pero no con el tamaño de la aorta ascendente. Estas observaciones indican que la dilatación aórtica puede tener mecanismos diferentes y, por consiguiente, requiere estrategias preventivas distintas según el segmento considerado.

Abbreviations

MSCT: multislice computed tomography
TA: thoracic aorta
TAC: thoracic aorta calcium

INTRODUCTION

It is important to determine the size of the thoracic aorta (TA) because its early increase may predict future aortic aneurysms whose frequency shows a continuous increase.[1] Estimating aortic size (ie, diameter, volume, tortuosity, tapering) is challenging because the anatomy of the TA is complex, particularly in the aortic arch region, which has several branches and a curvilinear nonplanar path that bends and twists.[2,3] We have recently shown that noncontrast low dose computed tomography for coronary artery calcium scoring allows reconstruction of the global morphology of the TA and simultaneously detection of thoracic aorta calcium (TAC).[4–7]

The Agatston TAC score is an indicator of atherosclerotic disease[8] and the opportunity to assess TA size and TAC simultaneously may allow analysis of the participation of atherosclerotic disease in the early dilatation of the TA according to the considered segment. Moreover, a detailed assessment of the association between aortic calcium and TA geometry could help to elucidate the heterogeneous distribution of calcium deposits along the length of the TA and help to detect vulnerable regions.[9]

In this study, we investigated the association of TA size with TAC in a cohort of 970 asymptomatic participants at increased cardiovascular risk. A detailed 3-dimensional geometric description of the TA and the position and size of TAC were simultaneously analyzed with customized software using nonenhanced extended multislice computed tomography (MSCT) scans. Logistic models adjusted for traditional risk factors were calculated to assess the specific role of the TA geometric variables on the presence of TAC and its extent and spatial distribution.

METHODS

Study Participants

Study participants (n = 970) were recruited over 2 years from September 2009.[4] We included all consecutive patients at risk for cardiovascular disease who underwent a noncontrast MSCT scan as part of a cardiovascular risk stratification program. This scan was performed as part of dual screening: *a)* estimation of calcified coronary atherosclerosis burden, and *b)* detection of early aortic dilatation in all TA sites including the ascending aorta, aortic arch and descending aorta. Informed consent was obtained from all individual participants included in the study. The participants had at least 1 traditional risk factor (hypercholesterolemia in 82%, hypertension in 49%, current smoking in 20% and diabetes in 9%). None of the participants had present or a past history of cardiovascular disease. The Framingham risk score calculated in all participants after recalibration for the French population was less than 20% at 10 years.[10] In accordance with the current guidelines,[11] we stratified the participants' risk of atherosclerotic cardiovascular disease by means of noncontrast low-dose MSCT for coronary artery calcium measurement. An extended scan was used to cover the entire TA for TAC assessment.[4] Brachial blood pressure was determined as the mean of 3 measurements using a sphygmomanometer with the patient in the supine position following a 10-min rest. Hypertension was defined as blood pressure of 140/90 mmHg or above, or use of antihypertensive medication. Total and high-density lipoprotein blood cholesterol and triglyceride concentrations were measured after a 14-hour fast, and low-density lipoprotein concentrations were calculated with the Friedewald formula or, when this formula could not be used, were measured directly. Hypercholesterolemia was determined by fasting low-density lipoprotein cholesterol above 3.3 mmol/L or by the presence of low-density lipoprotein-lowering drug therapy. Blood glucose was measured after an overnight fast and diabetes was determined by fasting blood glucose of 7 mmol/L or above, or by the presence of antidiabetic medication.

The retrospective analysis of personal health data of study participants was authorized by the CNIL *(Commission nationale de l'informatique et des libertés)* and was in accordance with the Declaration of Helsinki.

Image Acquisition

Aortic imaging was obtained with noncontrast cardiac 64-slice MSCT (Light-speed VCT, GE Health care; Milwaukee, Wisconsin, United States) during the acquisition done to quantify coronary artery calcium as reported elsewhere.[4] The measurements were done with 2.5-mm axial slices, 120 kVp, 250-mA tube current, 250-ms exposure time, and a 250-mm field of view. Images were acquired with prospective-electrocardiogram gating at 60% of the R-R interval in the craniocaudal direction from the top of the aortic arch to the level of the diaphragm. The effective radiation dose assessed in a representative subgroup of 200 participants using this extended scan length was 1.23 ± 0.14 mSv.[6] Scans were exported as DICOM (Digital Imaging and Communication in Medicine) files and were analyzed using a customized software designed in our laboratory that estimated the TA geometry in 3 dimensions[6] and calculated the size and position of the TA calcifications.[4] Thoracic aortic size and calcium were measured by the same expert, blinded to clinical parameters. Further details can be found in previous reports.[4–6]