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Original article

Impact of Calcium Score on Agreement Between Multidetector Computed Tomography and Invasive Coronary Angiography

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ABSTRACT

Introduction and objectives: Multidetector computed tomography (MDCT) has been demonstrated as a feasible alternative to invasive coronary angiography (ICA). However, contradictory results have been reported regarding the effect of coronary artery calcium score (CS) on the diagnostic accuracy of MDCT. Our aim was to assess the agreement of MDCT and ICA and to evaluate the influence of CS on this agreement.
Methods: We enrolled 266 consecutive patients who underwent evaluation with 64-slice MDCT and ICA. Standard CS software tools were used to calculate the Agatston score. Stenosis was qualitatively classified as mild, moderate, or severe by 1 blinded observer and the results were compared with those of ICA, which was used as the gold standard.
Results: The mean age of the patients was 65.4 ± 11.2 years, and 188 patients (70.3%) were men. A total of 484 segments with coronary stenosis ≥ mild were qualitatively evaluated and quantified with MDCT. Noninvasive measurements were concordant with ICA in 402 stenoses (83.05%; Kappa, 0.684), with no significant differences between vessels and with no statistically significant influence of CS on this agreement (OR, 0.93; 95%CI, 0.76-1.09; *P* = .21). Multidetector computed tomography had high sensitivity, specificity, positive predictive value, and negative predictive value on a per-segment, per-vessel, and per-patient basis.
Conclusions: Non-ICA using MDCT showed good agreement with ICA in the qualitative quantification coronary stenosis and CS had no significant impact on this agreement.

Impacto de la puntuación de calcio en la concordancia entre la tomografía computarizada con multidetectores y la coronariografía invasiva

Palabras clave:
Puntuación de calcio
Tomografía computarizada
Angiografía coronaria

RESUMEN

Introducción y objetivos: Está demostrado que la tomografía computarizada con multidetectores (TCMD) es una alternativa factible a la coronariografía invasiva (CI). Sin embargo, se han indicado resultados contradictorios sobre el efecto de la puntuación de calcio (PC) coronario en la precisión diagnóstica de la TCMD. El objetivo de este estudio es evaluar la concordancia entre la TCMD y la CI y evaluar la influencia de la PC en ella.
Métodos: Se incluyó a 266 pacientes consecutivos sometidos a evaluación por TCMD de 64 cortes y por CI. Se utilizó el *software* habitual para la PC mediante el método Agatston. Un observador clasificó cualitativamente y de manera enmascarada las estenosis como leve, moderada o grave, y se compararon con los resultados obtenidos por la CI, utilizada como método de referencia.
Resultados: La media de edad de los pacientes era 65,4 ± 11,2 años, y 188 (70,3%) eran varones. Se evaluó cualitativamente y se cuantificó por TCMD un total de 484 segmentos con estenosis coronaria al menos leve. Las mediciones no invasivas concordaban con la CI en 402 estenosis (el 83,05%; kappa = 0,684), sin diferencias significativas entre vasos y sin una influencia estadística significativa de la PC en la concordancia (OR = 0,93; IC95%, 0,76-1,09; p = 0,21). La TCMD tuvo sensibilidad, especificidad, valor predictivo positivo y valor predictivo negativo altos en los análisis por segmento, por vaso y por paciente.
Conclusiones: La coronariografía no invasiva mediante TCMD mostró buena concordancia con la CI en la cuantificación cualitativa de las estenosis coronarias, y la PC no tuvo un impacto significativo en esa concordancia.

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Abbreviations

CS: calcium score
ECG: electrocardiogram
ICA: invasive coronary angiography
MDCT: multidetector computed tomography

INTRODUCTION

Over the past few years, multidetector computed tomography (MDCT) has been demonstrated as a feasible alternative to invasive coronary angiography (ICA), allowing noninvasive evaluation of the coronary arteries.[1–4] However, contradictory results have been reported regarding the effect of coronary artery calcium score (CS) on the diagnostic accuracy of MDCT.[5,6] With the first generations of MDCT scanners, severe coronary calcifications were recognized as an important factor hampering precise evaluation of coronary artery stenosis, thereby limiting diagnostic accuracy. Calcified plaques produce artifacts (blooming) which may affect the evaluation of luminal obstruction.[7] At the same time, more extensive coronary calcification increases the likelihood that the patient has obstructive coronary artery disease,[8,9] and ICA is usually required for definitive diagnosis and treatment. Advances in temporal and spatial resolution, especially the introduction of 64-detector rows, and growing experience concerning strategies for optimization of image quality, have allowed high-quality noninvasive angiograms to be conducted in most patients. The purpose of the present study was to evaluate the validity and agreement of MDCT and ICA in patients with coronary artery disease and to evaluate the impact of coronary artery CS on the diagnostic accuracy of MDCT.

METHODS

Study Population

A total of 271 consecutive patients who were evaluated with 64-slice MDCT and who subsequently underwent ICA were evaluated; 5 patients were excluded because of a lack of image quality (eg, coronary motion, vessel size, breathing artifacts) or technical scan insufficiencies (eg, scan abortion, misplaced scan range, poorly executed contrast media timing, or electrocardiogram [ECG] misregistrations), resulting in a final sample of 266 patients. Demographic and clinical characteristics, including age, sex, cardiovascular risk factors (hypertension, diabetes mellitus, hyperlipidemia, smoking status), kidney failure, and peripheral arterial disease were identified. Kidney failure was defined as a serum creatinine level of more than 1.3 mg/dL (115 μmol/L). Patients with atrial fibrillation, significant renal insufficiency, or a history of significant iodinated contrast allergy were excluded. In addition, we excluded those with a previously documented history of obstructive coronary artery disease. The decision to perform ICA and MDCT was taken by the patient's physician in all cases based on age, risk factors for coronary artery disease, and the severity or persistence of symptoms. All patients gave written informed consent for ICA and MDCT.

Multidetector Computed Tomography Acquisitions

MDCT data were acquired using Brilliance 64 MDCT (Philips Medical Systems, Best, The Netherlands). Before CS and MDCT examinations, heart rate and blood pressure were monitored. In the absence of contraindications, participants received propranolol (5-15 mg intravenously) if the resting heart rate exceeded 65 bpm. All participants were in sinus rhythm. The heart rate of all participants ranged between 45 and 77 bpm (average, 62 $\pm$ 6 bpm) with or without premedication. Sublingual nitroglycerin was routinely used 1 minute before MDCT to dilate coronary arteries. The participants were imaged in the supine position. The participants were instructed to maintain an inspiratory breathhold during which the MDCT data and ECG trace were acquired. Scanning was performed from the tracheal bifurcation to 1 cm below the diaphragmatic portion of the heart. First, an ECG-gated scan without contrast media was performed to determine the CS. After a scout scan, a volume of 80 to 120 mL of contrast media (iopamidol 370 mg/mL, Bracco) was injected intravenously via an 18-gauge catheter placed in the antecubital vein, at a rate of 5 mL/s and controlled with a bolus-tracking technique, followed by a 50-mL bolus of saline. Scanning started automatically with a delay of 5 seconds after a predefined threshold of 140 HU was reached in the aortic root. Scanning was performed at 120 kV, with an effective tube current of 600 to 1000 mAs, slice collimation of 64 $\times$ 0.625 mm acquisition, gantry rotation time of 0.4 seconds, and pitch of 0.2. Image reconstruction was routinely performed using the retrospective ECG-gating method. A prospective ECG-gated scan using the "step-and-shoot" protocol was only performed in thin patients with a heart rate $<$ 65 bpm. In this study, 67.4% of the MDCT examinations were retrospective and 32.6% were prospective. The effective dose of MDCT was estimated from the dose-length product and an organ weighing factor [$k = 0.017$ mSv $\times$ (mGy $\times$ cm)$^{-1}$] for the chest as the investigated anatomical region.

Image Processing and Analysis

Postprocessing of the CS and MDCT examinations was performed on dedicated workstations (Philips Extended Brilliance Workspace). For each study, a CS was determined using the methods of Agatston et al.[10] Coronary CS was measured without contrast using semiautomatic software (HeartBeat CS, Philips Medical Systems), which displayed colored spots for calcium to be manually marked by the operator and automatically calculated all spots to a summed CS (Figure). A CS was calculated for each epicardial coronary segment and recorded as a composite (ie, total or summed) score for the entire epicardial coronary system (left main, left anterior descending, left circumflex, and right coronary arteries). Contrast-enhanced multidetector computed tomograms were examined for the presence of obstructive coronary luminal narrowing in all available segments. The MDCT angiograms were examined using axial slices, curved multiplanar reconstructions, and maximum intensity projections (Figure). Coronary arteries were divided into 17 segments based on modified recommendations of the American Heart Association.[11] Each vessel was analyzed on at least 2 planes, 1 parallel and 1 perpendicular to the course of the vessel. Semiquantitative assessment was performed on all segments of the coronary artery tree, with an estimate of stenosis severity calculated as the ratio of the minimum contrast lumen over the normal reference lumen of an unaffected distal portion. Severe coronary stenosis was defined as reduction $>$ 70% of the lumen diameter, moderate as a reduction of 50% to 70% of the lumen diameter, and mild as a reduction $<$ 50% of the lumen diameter. Scans were analyzed through consensus of an experienced radiologist and a cardiologist, who were both blinded to the clinical history. Discrepancies were resolved after additional joint review and discussion.

Statistical Analysis

Continuous variables are presented as mean $\pm$ standard deviation. Categorical data are presented as absolute frequencies

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