ORIGINAL ARTICLE

# Utility of coronary computed tomography to rule out acute coronary syndrome in the emergency department: a pilot study

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**Received:**
16-2-2010

**Accepted:**
26-2-2010

**Conflict of interest:**
Dr. Òscar Miró received a research grant from the Instituto de Salud Carlos III during 2009. Dr. Ortiz-Pérez received a clinical research grant from the Sociedad Española de Cardiología in 2008 and a grant from the Fondo de Investigación Sanitaria para Evaluación de Tecnologías Sanitarias 2009 (PI 09/90513). This study was partly funded by the Generalitat de Catalunya (SGR-2009-1385).

**Objective:** To analyze the diagnostic contribution of coronary multidetector computed tomography (CMCT) in low-risk chest pain patients.
**Methods:** Retrospective, descriptive substudy as part of a prospective study of the diagnostic yield of stress echocardiography in comparison with CMCT angiography. The setting was a non-traumatic chest pain unit. Patients with chest pain but without diagnosed coronary artery disease and fewer than 2 coronary risk factors in 2008 were included if the information usually gathered to diagnose acute coronary syndrome (ACS) (ie, medical history, electrocardiogram, troponin series, and ergometry) was negative. Clinical and patient data were recorded and CMCT was performed; if abnormalities were detected, heart catheterism was undertaken.
**Results:** Of the 502 patients suspected of having ACS while CMCT was available to the department, 54 (10.7%) met the criteria for performing the procedure. CMCT demonstrated normal coronary arteries in 35 (64.8%). In 3 (5.5%) the findings could not be interpreted due to artifacts and in 16 (29.6%), abnormalities were detected. Catheterization was performed in 15 of the 16 patients; the test was positive in 10. CMCT led to a diagnosis of ACS in an additional 2% of the group of patients in whom the diagnosis was initially suspected and in 18.5% of the 54 patients included in the CMCT study.
**Conclusions:** CMCT contributed additional diagnoses of ACS when the procedure was used to complement the standard protocol (history, ECG, troponin series, and ergometry) in patients with chest pain. [Emergencias 2010;22:101-108]

**Key words:** Cardiac computed tomography. Chest pain. Coronary arteriography.

## Introduction

The correct diagnosis of acute coronary syndrome (ACS) in the emergency department (ED) is a challenge that remains to be met despite numerous diagnostic advances. Until recently it was considered that in certain areas, especially North America, up to 75% of hospital cardiology department admissions from the ED for suspected ACS were inappropriate[1]. In addition, 2-10% of patients with chest pain that in fact had ACS were erroneously discharged from the ED[2]. Chest pain units (CPU) appeared in order to reduce these two above-mentioned percentages. Our ED has had a CPU since 2002.

Since then, we have found that diagnostic doubts about the coronary origin of the pain persist after completion of electrocardiogram (ECG)

and cardiac troponin (cTn)[3] immunoassay in 40% of patients treated for non-traumatic chest pain. In these cases, some form of induced ischemia testing is necessary (conventional stress, pharmacological or echocardiographic test) to increase the diagnostic yield in these patients and thereby limit unnecessary admission and inappropriate discharge. Even with this, the problem is not fully resolved. Indeed, there is an undefined percentage of false negative results in induced ischemia tests which help perpetuate the inappropriate discharge of patients with acute coronary disease[4].

In recent years, continuous advances in the temporal and spatial resolution of multidetector CT (MDCT) scanners have allowed improved ability to study the anatomy of the coronary tree in a non-invasive way[5-7]. Those hospitals that have incorporated MDCT have an additional tool which is potentially applicable to the study of patients attending the ED with chest pain. In 2007, MDCT was installed at our center as a pilot resource, and is available for emergency use on weekdays from 9am to 2pm. The aim of this study was to analyze the potential diagnostic role of coronary MDCT, in a subgroup of chest pain patients with low coronary risk, in ruling out or confirming pain to be of coronary origin.

## Method

This paper reports on a descriptive and retrospective pilot sub-study of a larger study to compare diagnostic performance of stress ultrasound and coronary MDCT angiography. It was carried out in the CPU of our ED, which caters for all patients with non-traumatic chest pain. The characteristics and diagnostic protocol used in the CPU have been described in detail in previous works[3]. Briefly, the CPU attends all patients over 18 years with non-traumatic chest pain, following the guidelines of the Spanish Society of Cardiology (SEC)[8]. Thus, once the ED physician has performed the initial clinical evaluation and the first ECG, patients are classified as: (i) ACS with ST elevation (STEACS), (ii) ACS without ST elevation (NSTEACS), (iii) possible ACS, and (iv) non-coronary chest pain (in this case, once the ED physician has established the final diagnosis, the patient is discharged, admitted or transferred to the ED observation area). Patients in the group of "possible ACS" may have normal or non-diagnostic ECG and ACS cannot be definitely ruled. They all remain in the CPU. Depending on the recurrence of symptoms, the emergence of new symptoms or ECG changes, and the value of troponin I, they are reclassified as STEACS, NSTEACS or non-coronary chest pain, or pending further study. STEACS patients are generally admitted. The latter receive a stress test according to the Bruce protocol, provided they are able to walk and their ECG is interpretable. If not, they receive an alternative induced ischemia test and the attending cardiologist decides on admission or not. Patients with negative stress test are discharged. If the result of the test is inconclusive, an alternative test is scheduled and, at the discretion of the cardiologist, discharged or admitted.

Of all the patients seen in the CPU during the year 2008 and corresponding to the group of "possible ACS", the present study included those without a history of heart disease disease, but with at least 2 coronary risk factors (CRF). Thus they were patients who consulted for chest pain, underwent the usual study procedures (medical history, ECG, seried cTn and induced ischemia test) and in whom ACS was reasonably ruled out. This pilot study, as described above, finally included patients with low-risk chest pain: it was approved by the Ethics Committee.

Patients were asked for their informed consent to be evaluated by the current diagnostic methods and 64-slice MDCT coronary angiography; subsequently, if the MDCT indicated coronary pathology, the patients were asked to consent to heart catheterization. Factors considered as coronary risk included smoking, diabetes mellitus, dyslipidemia and hypertension. The presence of at least two of these risk factors was required to improve the diagnostic performance of the study. We recorded clinical and epidemiological data that were entered in a confidential anonymous data table created for this purpose. Finally, we also recorded CPU activity limited to the days and hours a day when MDCT was available (weekdays, 9-14 h).

For logistical reasons, we excluded chest-pain patients attending after MDCT-available hours; for clinical reasons we excluded those younger than 35 years (with low probability of coronary artery disease), those with chest pain at the time the test was indicated or those with hemodynamic instability (systolic blood pressure lower than 90 mmHg); for technical reasons, we excluded those with known history of ischemic heart disease (for the existence of prior coronary tree disease that could impede interpretation), and those with non-sinusoidal heart rhythm and heart rate above

80 beats per minute (bpm) or altered renal function (creatinine >1.3 mg / dL).

For the MDCT angiography procedure, patients with heart rates above 65 bpm were treated with beta-blockers (oral atenolol or intravenous propranolol) until achieving a heart rate of less than 65 bpm. First, a non-helical acquisition was obtained without contrast with a thickness of 3 mm to calculate calcium score (Agatson score). Due to the difficulty of interpreting coronary lumen in patients with severe coronary calcification, in cases with Agatson score> 400 angiography was not performed. The remaining cases received 400 mcg of sublingual nitroglycerin immediately before MDCT acquisition. The studies were conducted using a 64-slice Siemens scanner (Sensation 64, Siemens Medical Solutions, Forchheim, Germany). For the angiography, we administered contrast (iomeron 380) at 5 cc per second of acquisition (approximately 70 ml of contrast), starting it automatically to reach a contrast density contrast in the ascending aorta greater than 120 Hounsfield units. The acquisition parameters were: 64 x 0.6 mm collimation, rotation time 370 msec (equivalent to a temporal resolution of 185msec); 120 kV tube voltage and effective tube current 850 mA. Whenever possible we used the dose modulation mechanism by optimizing the acquisition to around 65% of the RR interval.

For the analysis of images, we reconstructed cardiac output with a slice thickness of 0.75 mm and increments of 0.4 mm to 60, 65 and 70% of the RR interval. If motion artifacts appeared, additional reconstructions were performed in different phases of the RR interval. Reconstructions were performed in several formats for subsequent interpretation including multi-slice reconstructions, maximum intensity projections and 3-D volumetric reconstructions. The average time for reconstruction and image analysis was 35 minutes per case. Each study was evaluated by a radiologist and a specialist and experienced cardiologist, according to a 16-segment coronary model, for the presence or absence of angiographic stenosis (≥50%) and non-evaluable segments, and the reason that prevented the assessment (motion artifact, severe calcification, etc.). Disagreements were resolved after study evaluation by a third observer.

Qualitative variables were recorded as absolute values and percentages, and quantitative variables as mean and standard deviation. Since this was a descriptive pilot study for exploratory purposes, sample size was not estimated inferential statistics were not used.

## Results

Figure 1 is a patient inclusion diagram. Of the 502 patients with possible ACS seen during the MDCT-available hours, we excluded 149 that did not complete the study, 24 with positive cTn, 10 with positive ischemia induction test, 224 with history of ischemic heart disease and 110 who did not have at least 2 CRF, only 69 (13.7%) were eligible to undergo coronary MDCT evaluation. Of these, 54 (10.7%) were finally included, and the characteristics of these patients are presented in Table 1.

MDCT showed normal coronary angiography or non-significant coronary lesions in 35 (64.8%) of these 54 patients (Figure 2). In 3 (5.5%) cases at least one proximal or middle segment of the coronary artery tree was not interpretable due to the presence of artifacts. Coronary angiography by MDCT was abnormal in 16 (29.6%) patients. In 14 cases we found at least one coronary lesion ≥50%, and the remaining two patients did not receive MDCT angiography because they presented an Agatson score >400. All patients with pathological MDCT underwent cardiac catheterization, except one patient with Agatson score ≥400 during admission, in accordance with the attending physician's indication. Finally, fifteen patients underwent cardiac catheterization; in 10 patients the presence of angiographically significant lesions (≥50% stenosis) was confirmed in the segments evaluated as pathological in the MDCT (Figure 3). All of them were diagnosed with ACS as a primary source of chest pain. In the 5 remaining cases, coronary heart disease was found but deemed not significant by a specialist in hemodynamics, representing 33% of MDCT false positives with respect to catheterization (Figure 4).

In summary, MDCT allowed the diagnosis of ACS in an additional 2.0% of the patients initially included in the group of "Possible ACS", i.e. 14.5% of those eligible for MDCT and 18.5% of patients finally included in the study. However, the use of MDCT was associated with a rate of 1% false positives amongst all the "Possible ACS" patients, and 9.2% of all the patients finally included in the study.

## Discussion

The main conclusion of this study is that coronary angiography using 64-slice MDCT can increase the diagnostic performance of a standard protocol (medical history, seried cTn, ECG and

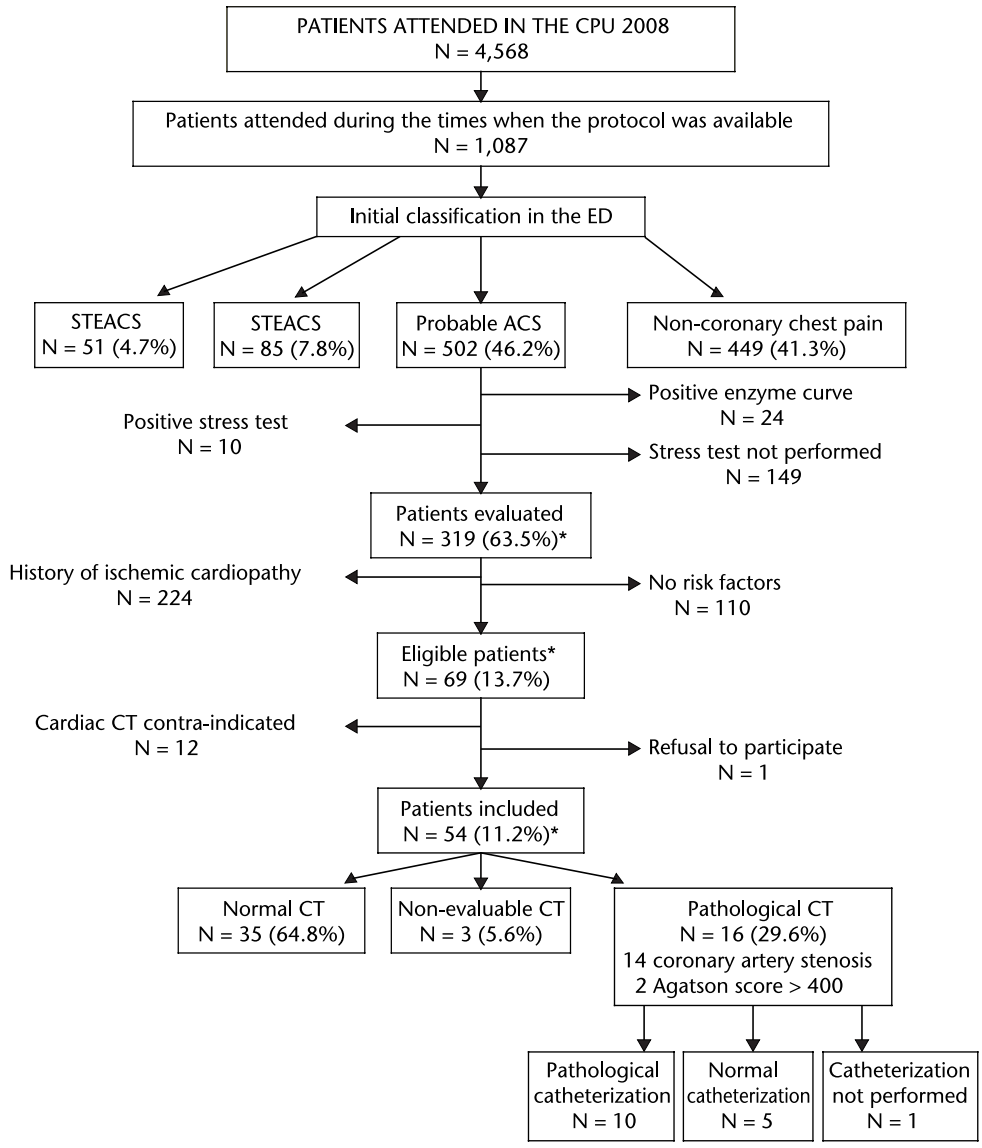


**Figure 1.** Diagram showing the inclusion of chest-pain patients. CPU: chest pain unit; CT: computed tomography. ACS: acute coronary syndrome. STEACS: ACS with ST elevation. NSTEACS: ACS without ST elevation.

ergometry) in the study of patients attending the ED with chest pain, and in particular, those with at least two CRF and no history of ischemic heart disease. Indeed, performance of MDCT coronary angiography when ACS was ruled out by the standard protocol allowed the recovery of 2% of patients with pathological findings and, therefore, indicated for conventional coronary angiography. ACS was confirmed in 66% of these patients that otherwise would have been improperly discharged. In addition, almost two thirds of the patients included showed normal MDCT findings, thus confirming the diagnosis of the standard protocol.

The diagnostic approach to patients attending the ED with non-traumatic chest pain is one of the major challenges for ED physicians. Considering the high mortality and morbidity of ACS patients discharged erroneously[2,8,9] and those undiagnosed, the importance of a precise and efficient approach should not be underestimated. To date, the diagnosis of these patients has largely depended on the clinical history, seried ECG and cTn test[3,8]. However, after completing this study, a number of patients with ACS do not have unequivocal diagnostic findings[2,8,9].

In recent years, for this group of patients, an

**Table 1.** Characteristics of the 54 patients who underwent coronary multidetector computed tomography

| | |
|---|---|
| Age | 60 ± 11 |
| Sex (male) | 34 (63.0%) |
| Diabetes | 6 (11.1%) |
| Dyslipidemia | 32 (59.3%) |
| Hypertension | 35 (64.8%) |
| Smokers or former smokers | 27 (50.0%) |
| Prior CVA | 2 (3.7%) |
| Family history of ischemic heart disease | 14 (25.9%) |
| Peripheral vascular disease | 2 (3.7%) |
| Pretest probability of HD[1] | 25 ± 17% |

CVA: cerebrovascular accident; HD: heart disease.
[1]Calculated as per Prior DB, et al. Am J Med. 1991; 90:553-62.

ischemia-induction test was recommended prior to discharge[7]. This practice has spread throughout our hospitals; in some cases this has led to unnecessary admissions for the test, and in others, the adoption of protocols in EDs to ensure such tests are performed before final discharge. The latter system, equally safe for the patient and more cost-effective, has been called the chest pain unit, which has been functionally[11-13] or structurally[3] implemented, depending on the hospital involved.

In recent years various authors have indicated that this approach to the patient with suspected ACS may possibly be insufficient[4,14,15]. That possibility is more likely when dealing with patients over 67 years of age with a history of coronary angioplasty, diabetic insulin-dependency, and more than two chest pain episodes in the last 24 hours[4]. The pretest probability of having an ACS in this group of patients is substantially higher than in the general population and also higher than in the population attending the ED with chest pain. This confirms that the CPU diagnostic protocol, including ischemia induction test, is most effective when applied to a population at low risk of coronary heart disease; when the test is negative, it has a very high negative predictive value but not 100%[16,17]. This pilot study suggests that 64-slice MDCT can improve this negative predictive value since it allows the detection of a small but clinically significant percentage of patients with negative stress test and coronary angiography with pathological MDCT.

MDCT was introduced in the late 1990s, with 4-slice devices which allowed non-invasive study of the coronary arteries for the first time. These were followed by 16-slice devices which proved more sensitive and specific and the currently used 64-slice MDCT[5-7].


**Figure 2.** Example of normal coronary angiographic multidetector CT image in a patient without coronary atherosclerosis. Curved multislice reconstructions of the circumflex (left), left anterior descending (middle) and right coronary artery (right) in a patient with normal coronary arteries.

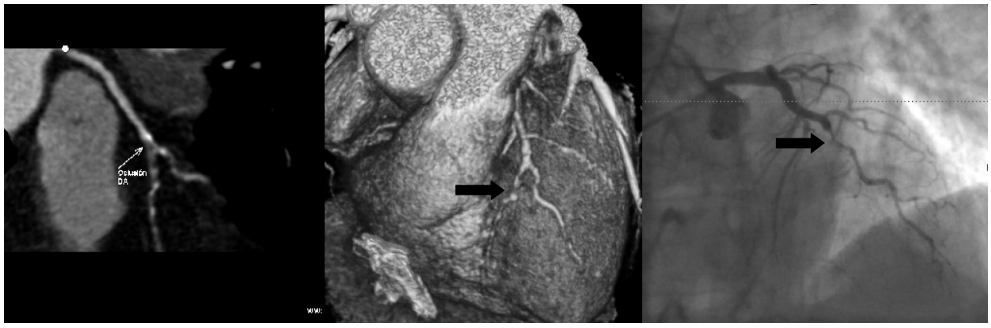


**Figure 3.** Concordance between multidetector CT and cardiac catheterization. Curved multislice reconstruction (left), three-dimensional reconstruction (center) and catheterization (right) in a patient with occlusion of the left anterior descending artery (arrows).

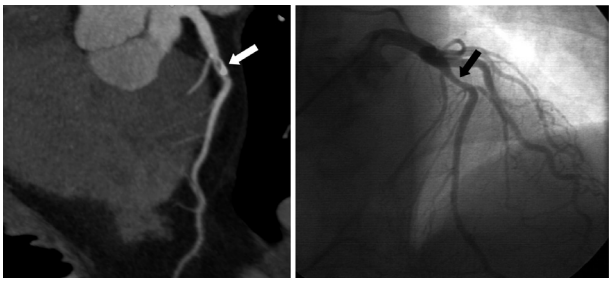

**Figure 4.** Example of discrepancy between multidetector CT (MDCT) and cardiac catheterization. MDCT image on the left showed a calcified lesion (left image, arrow) at proximal anterior descending artery with estimated stenosis > 70% which was quantified as less than 50% by cardiac catheterization (right image, arrow).

The latter allow examination of all segments of the coronary tree, and are increasingly becoming the gold standard for the exclusion of significant coronary stenosis because of its high negative predictive value7. Thus, a recent study by Cazales et al[18] studying the accuracy of 64-slice MDCT as compared with classical coronary angiography found that 90% of the coronary tree was displayed and susceptible to interpretation, and 94% agreement. However, the new method still presents certain difficulties of interpretation, involving both false positives and false negatives.

The excellent results referred to above have led to a proliferation of small studies with a more clinical focus, which have attempted to establish the value of coronary MDCT for the management of ED patients with chest pain. Despite small sample sizes, the results have shown a high degree of uniformity and agreement on negative predictive value for ACS when MDCT is normal[19,20]. More recently, Hoffmann et al[21] studied a cohort of 1,869 patients attending the ED with chest pain and a non-diagnostic initial ECG and normal cTn. The authors specifically excluded patients, among others, with a history of ischemic heart disease and / or contraindication for the implementation of MDCT, which reduced the sample to 1270 patients. Finally, 368 patients underwent coronary MDCT prior to admission. The attending physicians were blinded to the results of MDCT and thus did not play a role in the medical decisions. They then quantified the number of ACS and adverse cardiovascular events during admission and again at 6 months. In the group with normal MDCT coronary angiography, corresponding to 50% of the final cohort, no adverse CV event was recorded during admission or follow up. On the basis of these results, MDCT sensitivity and negative predictive value was 100%.

In another study of a prospective cohort of 568 patients with low-risk chest pain (TIMI 2 or less) and non-diagnostic first ECG, the diagnostic performance of coronary MDCT just after a non-diagnostic ECG (without performing seried ECG, cTn curve) was compared with that of the usual procedure (history, seried ECG, cTn curve and in some cases stress test)[22]. The authors recorded any deaths from cardiovascular causes or events of myocardial infarction at 30 days. In the MDCT group with normal result (245 of 285) there was no adverse cardiovascular event. This finding again confirms the 100% negative predictive value of coronary MDCT, but also significantly shortened ED stay, from 20.8h in the group receiving the usual procedure to 7.1 hours. These results, based on dispensing with the usual cTn test for one of the groups, are highly encouraging but clearly require further confirmation. Finally, as in our study, some patients in the second group with negative stress test showed pathological coronary MDCT.

Despite these encouraging findings, coronary angiography using 64-MDCT has limitations that should be taken into consideration for possible future use. Among these are those inherent to any examination involving contrast and the level of radiation for the patient; the patient must not present tachycardia and must be able to cooperate and hold their breath. There are also considerable difficulties with the interpretation of results when the patient has known coronary artery disease, especially when bearing stents. Future generations of CT devices should help to remedy several of these limitations.

Finally, this study has some noteworthy limitations. It is a retrospective sub-study of a larger prospective study designed to compare the diagnostic performance of stress echocardiography and MDCT. However, the results support the growing evidence of this technique as a diagnostic test from a different perspective: that of demonstrating that it can detect ACS in a subgroup of low-risk patients with negative stress test. Confirmation of these findings could help prevent a certain percentage of inappropriate discharge. The study was performed in a single center, with sample inclusion limited to standard working hours. Due to the exclusion of patients with a history of ischemic heart disease and renal failure, the population of greater age may be poorly represented. Furthermore, a group of dedicated and skilled physicians was responsible for the interpretation of coronary MDCT results. Their considerable experience in interpretation may not be equally re-

producible with examinations performed by other radiologists.

Finally, MDCT involves a cost that could limit its application to only the major hospitals. However, this must be weighed against the potential decrease of inappropriate admission and / or discharge; it is possible that a comprehensive cost-benefit study could show that MDCT in the ED is beneficial.

Beyond the precise role of coronary MDCT in the future in diagnostic protocols for patients attending the ED with chest pain, our results suggest that coronary MDCT is capable of improving the performance of current diagnostic protocols used in these patients. If confirmed in future prospective randomized studies, the diagnostic challenge posed by patients with chest pain will be closer to being met.

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## Estudio piloto de la utilidad de la tomografía computarizada cardiaca para descartar síndrome coronario agudo en urgencias

**Miró O, Ortiz-Pérez JT, León R, López B, Perea R, De Caralt TM, Sitges M, Paré C, Bosch X, Bragulat E, Sánchez M**

**Objetivo:** Analizar, en pacientes con dolor torácico de bajo riesgo, las aportaciones de la coronariografía por tomografía computarizada multidetector (TCMD) en el diagnóstico de síndrome coronario agudo (SCA).

**Método:** Subestudio piloto descriptivo y retrospectivo de un estudio prospectivo que comparaba la rentabilidad diagnóstica de la ecografía de estrés con la angiografía por TCMD. Se realizó en una unidad de dolor torácico (UDT) que atiende a pacientes con dolor torácico no traumático. Se incluyeron, en 2008, pacientes sin coronariopatía conocida y con al menos 2 factores de riesgo coronario y dolor torácico con estudio habitual (historia clínica, electrocardiogramas, troponinas seriadas y ergometría) negativo para SCA. Se registraron datos clínicos, epidemiológicos y se les realizó una coronariografía por TCMD y, si era patológica, un cateterismo.

**Resultados:** De los 502 pacientes con posible SCA atendidos durante la disponibilidad de la prueba, 54 (10,7%) cumplían criterios para la TCMD. La TCMD mostró coronarias normales en 35 (64,8%); en 3 (5,5%), no interpretables por

artefactos; y en 16 (29,6%) la TCMD fue patológica. En estos últimos, se practicaron 15 cateterismos, de los que 10 fueron patológicos. Así, la TCMD permitió el diagnóstico de SCA en un 2,0% adicional de los pacientes incluidos inicialmente en el grupo de posible SCA y el 18,5% de los 54 pacientes finalmente incluidos.
**Conclusiones:** La TCMD cardiaca aumentó el rendimiento diagnóstico de un protocolo estándar (historia clínica, electrocardiogramas y troponinas seriadas y ergometría) en los pacientes con dolor torácico. [Emergencias 2010;22:101-108]

**Palabras clave:** Tomografía computarizada cadiaca. Dolor torácico. Coronariografía.