

# Role of new imaging techniques in the emergency department diagnosis of acute coronary syndrome

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The rapid triage of patients who come to the emergency department with chest pain continues to be a medical challenge, one that has important economic implications for health-care systems. When electrocardiographic (ECG) abnormalities or elevated markers of myocardial necrosis are found, management is relatively straightforward. However, a considerable number of patients have negative ECGs or troponin tests. Noninvasive imaging techniques have therefore become important tools for decision-making in such cases. Cardiac computed tomography can reveal the degree of coronary calcium deposition present and show coronary arteries noninvasively, rapidly, and accurately. Cardiac magnetic resonance imaging provides important information concerning the functional impact of coronary disease. Using these techniques in the management of emergency patients with chest pain can potentially increase efficiency, reduce unnecessary admissions, and provide an accurate diagnosis more quickly. The aim of this review is to discuss the usefulness and limitations of cardiac computed tomography and magnetic resonance imaging for emergency room treatment of patients who are suspected of having acute coronary syndrome. [Emergencias 2010;22:125-129]

**Key words:** Chest pain. Acute coronary syndrome. Emergency health services.

## Introduction

Chest pain (CP) is the second most frequent reason for care demand in the emergency department (ED)<sup>1</sup>. The rapid classification of patients with CP is essentially to differentiate acute coronary syndrome (ACS) from other causes. This represents a medical challenge and an important issue from the economic point of view for health systems. In general, the initial stratification is based on clinical history, electrocardiogram (ECG) and blood tests to determine markers of myocardial necrosis. When electrocardiographic (ECG) abnormalities or elevated markers of troponin are found, the decision is relatively clear: hospitalization and coronary angiography are usually indica-

ted. However, a significant percentage of CP patients have negative enzyme test and normal or nonspecific ECG. Such patients are often admitted to the hospital or specialist CP units for longer observation and undergo serial troponin tests and further ECG, which usually involves a stress test. Stress echocardiography and cardiac computed tomography (CT) with single photon emission (SPECT) are non-invasive imaging techniques habitually used in this context. Both provide additional information for diagnosis and risk stratification on detecting changes in segmental motility or myocardial perfusion suggestive of significant coronary heart disease<sup>2</sup>, and they have proved to be cost-effective in the management of patients with acute CP<sup>3,4</sup>. The drawbacks are that both techni-

ques involve long procedures, serial enzyme determination before physical or chemical stress test, and the attention of specifically trained personal not generally available 24 hours a day every day of the week.

The current strategy for assessing patients with acute CP by prolonged observation and further investigation is costly for health systems and continues to lead to erroneous diagnosis in 2-8% of patients with ACS<sup>5</sup>. New non-invasive imaging techniques such as cardiac CT (CCT) and cardiac magnetic resonance (CMRI) have emerged as promising alternatives for the diagnosis of CP in the ED. Their use could increase efficiency, reduce unnecessary admissions and lead to rapid and accurate diagnosis.

### Cardiac CT: usefulness and limitations

CCT offers a rapid, non-invasive and accurate view of coronary anatomy, which makes it an attractive tool for the management of patients with acute CP.

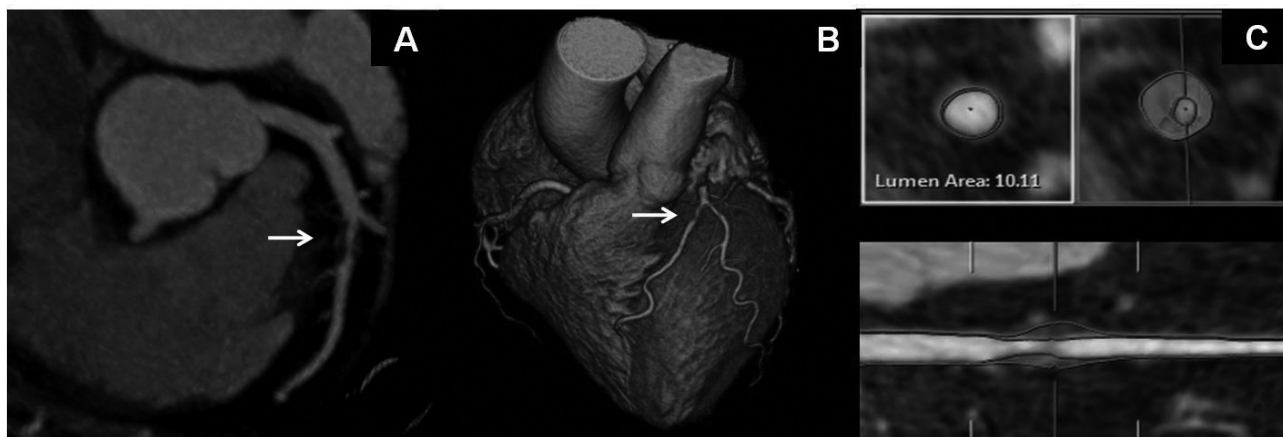
The quantification of coronary calcium is the simplest technique since it does not require contrast and radiation dose for the patient is very low. There is good correlation between quantification of calcium, usually expressed as Agatston score, and the burden of atherosclerosis. In the context of CP in the ED, published studies have shown that calcium score has high sensitivity and negative predictive value for the detection of significant coronary artery disease. However, its specificity is limited, especially in patients with known coronary disease<sup>6</sup>. It is also important to note that CCT alone does not allow one to assess the severity of coronary stenosis, nor does it identify non-calcified plaques.

These limitations are resolved with non-invasive coronary angiography. By spiral or sequential acquisition synchronized with the ECG during apnea of approximately 10 seconds (64-slice) and the injection of 60-80 ml iodinated contrast, images are obtained which are then reconstructed in different phases of the cardiac cycle for analysis. Compared with invasive angiography, the CCT has a sensitivity and specificity around 91 and 96% respectively, and negative predictive value of 99-100% for the detection of significant CAD<sup>7</sup>. Studies on CP patients in the ED have shown high diagnostic accuracy and safety in relation to the diagnosis of ACS and adverse cardiac events<sup>8-10</sup>, and greater cost-effectiveness than exercise SPECT, reducing the time to diagnosis and therefore allo-

wing early discharge<sup>8,11</sup>. An additional advantage of CCT is that it allows simultaneous evaluation of global and segmental ventricular systolic function with similar precision to that of echocardiography or CMRI<sup>12</sup>, and can even identify areas of myocardial perfusion and report on perfusion in repose<sup>13</sup>. Specifically, the differential diagnosis of CP in the ED, the CCT allows simultaneous examination of non-cardiac structures such as the aorta and pulmonary arteries, which can rule out the three potentially most serious causes of chest pain (triple rule out): ACS, aortic dissection and pulmonary embolism<sup>14</sup>. Finally, an interesting feature of CCT is that, unlike coronary angiography, it assesses the arterial wall directly, and therefore the total burden of atherosclerosis can be estimated more accurately, which may facilitate better risk stratification and treatment of patients. New programs are available to quantify the composition of plaques according to the degree of attenuation in Hounsfield units (Figure 1). Evidence of low plaque attenuation could be used in future for risk stratification in the ED, as this is known to be more frequently associated with ACS<sup>15</sup>.

It is important to know the limitations of CCT, as they may affect application in the ED. There are several factors that influence the diagnostic quality of images, such as high frequency or irregular heart rate, the difficulty of getting patients to perform correct apnea or the presence of coronary stent or significant coronary calcification.

However, new devices (double tube 256-slice scanners) have significantly reduced the impact of these factors on image quality. Exposure to radiation is another important consideration. Using protocols of dose modulation and the acquisition of images in just one part of the cardiac cycle (prospective protocol) can reduce the dose of radiation to less than 5 mSv, lower than the doses required in coronary angiography (5-6 mSv) or SPECT (10-12 mSv). Finally, as with coronary angiography, CCT only provides anatomical data but no information about their physiological relevance, which is especially important in cases of intermediate stenosis. In relation to decision making in the ED, randomized studies are under way (ROMICAT II) and clinical registries (SPARC Michigan Blue Cross and Blue Shield) that will help us to resolve issues like whether negative calcium score, or the absence of significant lesions (defined as greater than 50%), confer sufficient reason in terms of safety for discharging patients without requiring a second determination of troponin.



**Figure 1.** Example of a cardiac CT study showing an obstructive lesion in the left anterior descending artery (arrow) in an axial slice (A) and a three-dimensional reconstruction (B). By means of a specific program, analysis of plaque composition can be performed, which in this case shows predominantly non-calcified content (C).

### Cardiac MRI: usefulness and limitations

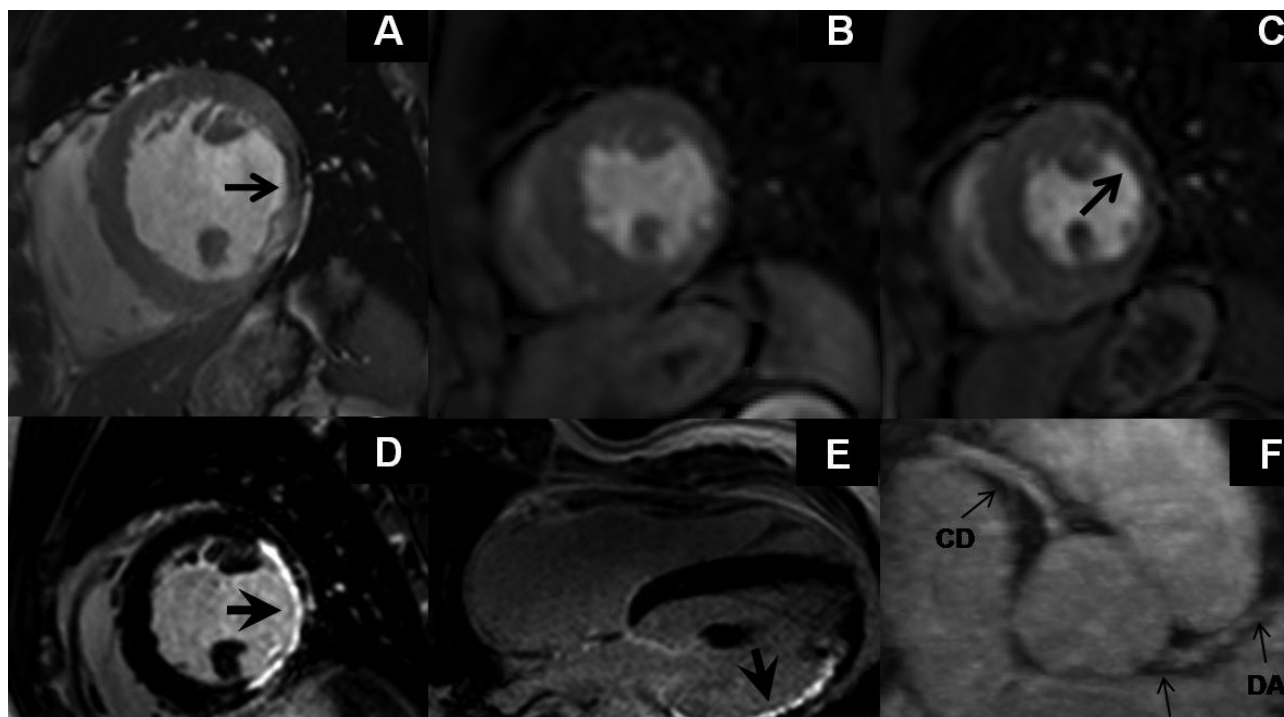
CMRI allows simultaneous evaluation of global and regional ventricular function, cardiac perfusion and myocardial viability, as well as cardiac anatomy and the presence of coronary artery disease (Figure 2). It is the gold standard for assessment of ventricular volumes, global cardiac function and alterations in segmental contractility, thus overcoming the limitations of echocardiography such as suboptimal acoustic windows. Detection of myocardial necrosis is possible using delayed enhancement sequences. After the administration of contrast (gadolinium), areas of infarction, fibrosis or scarring are more brilliant when compared with normal myocardium and thus allow one to locate and quantify the extent of transmural myocardial injury. Additionally, T2-weighted sequences show increased signal intensity in areas of edema and inflammation, and facilitate differentiation between areas of acute and chronic infarction with high specificity<sup>16</sup>. Few studies have assessed the utility of CMRI in the ED. A study by Kwong et al. including 161 patients with acute CP showed that CMRI is feasible in the ED and adds diagnostic information to clinical information, ECG and troponin I<sup>17</sup>. Another study in patients with ACS without ST elevation showed 96% sensitivity and 83% specificity for the detection of significant coronary artery disease<sup>18</sup>. CMRI after stress test with adenosine or dobutamine allows one to identify perfusion defects in the myocardium due to obstruction of both the epicardial coronary arteries and the myocardial microvasculature, which are difficult to detect with other diagnostic techniques<sup>19</sup>. CMRI has demonstrated a sensitivity of 100% in predicting signifi-

cant coronary disease and cardiac events in follow up of CP patients presenting at the ED with normal ECG and negative troponin<sup>20</sup>. The study of coronary anatomy using CMRI is evolving, but currently only proximal and middle segments can be assessed, so its application in the ED is still limited.

The main advantages of CMRI in relation to other non-invasive imaging techniques include the absence of radiation compared with SPECT and CCT, high spatial resolution compared with SPECT, and the possibility of combining several sequence types in a single scan to acquire three-dimensional images. However, its possible ED use is restricted by the need for long image-acquisition time, motion and breathing artifacts, reduced availability due to the high cost of the devices and processing equipment, and the need for experienced operators, as well as contraindications specific to MRI (metal prostheses, claustrophobia and morbid obesity).

### Conclusions

In summary, non-invasive imaging techniques play an important role in the management of CP patients with intermediate risk. Calcium score detects the presence of atherosclerosis with the advantages of low radiation and without the need for contrast, but does not provide information on the degree of stenosis or the presence of non-calcified plaques. CTT allows direct visualization of the coronary artery with a negative predictive value approximating 100%, so it has become a valuable test to rule coronary heart disease. In the event of neighbouring lesions, additional functio-



**Figure 2.** Example of a cardiac MRI in a patient with ischemic cardiopathy. Cine sequences show (A) systolic dysfunction with myocardial thinning in the lateral side (arrow). Sequences of perfusion at rest (B) and after administration of adenosine (C), revealed a perfusion defect in the lateral side that disappeared at rest (arrow), suggestive of peri-infarction ischemia. Late enhancement (D and E) shows an area of necrosis in the same area (arrow). Visualization of the coronary arteries (F) allowed ruling out significant disease in the common trunk (TC) and proximal left anterior descending artery (DA) and right coronary artery (CD).

nal tests are required for the proper management of these patients. Finally, CMRI is emerging as an alternative diagnostic technique that may be used in the ED; it is highly useful for assessing the functional significance of heart disease but remains a complex technique. Further studies are needed to evaluate its cost-effectiveness, which may allow it to become standard equipment in the emergency department.

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## Papel de las nuevas técnicas de imagen en el diagnóstico de síndrome coronario agudo en urgencias

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La clasificación rápida de los pacientes que acuden a urgencias con dolor torácico continúa siendo un desafío médico y una cuestión importante desde el punto de vista económico para los sistemas de salud. Cuando existen cambios en el electrocardiograma (ECG) o elevación de marcadores de necrosis miocárdica, el manejo de los pacientes es relativamente claro. Sin embargo, existe un número considerable de pacientes en los que el ECG y las troponinas son negativas. En estos pacientes las técnicas de imagen no invasivas se han convertido en una herramienta importante para la toma de decisiones. La tomografía cardíaca permite cuantificar la cantidad de calcio coronario y visualizar directamente las arterias coronarias de forma no invasiva de una forma rápida y precisa. La resonancia magnética cardíaca aporta una importante información sobre la significación funcional de la enfermedad coronaria. La utilización de estas técnicas en el manejo de pacientes que acuden a urgencias con dolor torácico agudo podría potencialmente aumentar la eficiencia, reducir ingresos innecesarios y conducir a un diagnóstico más rápido y exacto. El objetivo de esta revisión es discutir la utilidad y limitaciones de la tomografía cardíaca y la resonancia cardíaca en el manejo de pacientes que acuden a urgencias con sospecha de síndrome coronario agudo. [*Emergencias* 2010;22:125-129]

**Palabras clave:** Dolor torácico. Síndrome coronario agudo. Servicio de urgencias.