ARTICLE

Experience with Multidetector Computed Tomography Changes in Acute Myocardiatis

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Abstract

Background: Acute myocarditis can present as an ACS with elevated ST segment and elevated level of troponin mimicking myocardial infarction. **Aim:** To determine the potential diagnostic value of ECG-gated multidetector computed tomography (MDCT) in the setting of suspected acute myocarditis. **Patients and methods:** The study group consisted of 12 consecutive patients admitted for suspected acute myocarditis less than 5 days after onset of symptoms. All patients had clinical, electrocardiographic signs, and laboratory findings consistent with the diagnosis. ECG-gated MDCT was performed in all patients and included a first-pass contrast-enhanced acquisition and a delayed low dose acquisition performed 5 min later without reinjection of contrast medium. 3 patients underwent cardiac MRI with injection of gadolinium. **Results:** The first-pass MDCT acquisition showed absence of coronary stenosis in all patients. Delayed MDCT acquisition, revealed multiple areas of sub epicardial myocardial hyperenhancement in 9 patients. This hyperhencement was confirmed in the 3 MRI examinations. **Conclusion:** ECG-gated MDCT could be a useful alternative non-invasive diagnostic test in the early phase of acute myocarditis, especially in the context of emergency and when MRI is unavailable.

Keywords: Multidectector Computed Tomography, Magnetic Resonance Imaging, Myocarditis, Acute Coronary Syndrome.

Introduction

Myocarditis is defined as an inflammation of heart muscle associated with oedema, cellular infiltration, apoptosis and necrosis of cardiomyocytes (1,2). The symptoms are often non specific raging from dyspnea, arrhythmia, and acute chest pain mimicking an acute coronary syndrome (ACS) to cardiogenic shock. Cardiac magnetic resonance imaging (CMRI) has been recently proved to be a powerful tool for the diagnosis of myocarditis (1,3) and is now considered

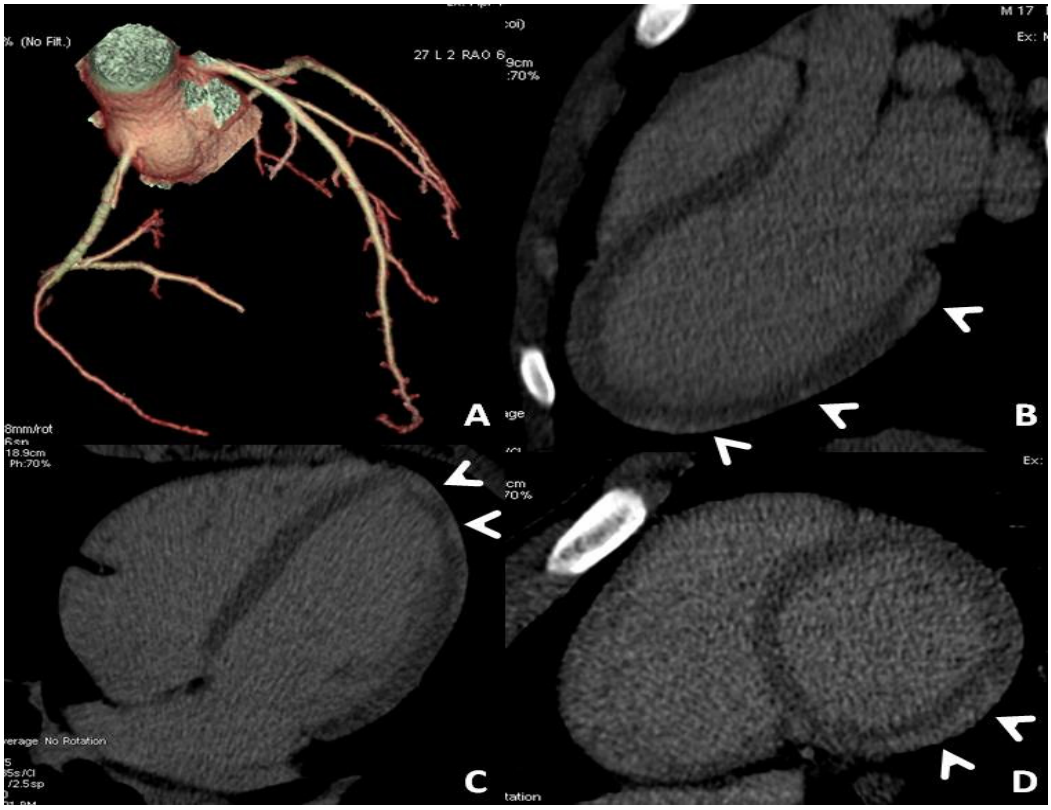

Figure1. 3 D Volume Rendering (VR) reconstruction on first pass acquisition of iodinated contrast-enhanced electrocardiogram (ECG)-gated multidetector computed tomography (MDCT) (A) showing the absence of significant artery lesion of the coronary system. Delayed acquisition 5 min after injection on three-chamber (B), four-chamber (C) and short-axis (D) views show subepicardial enhancement (arrowheads).

as an alternative to endomyocardial biopsy (an invasive examination not without risk). Since access to CMRI is not easy especially in an emergency context, we attempted to determine the potential diagnostic value of contrast enhanced ECG-gated multidectector computed tomography (MDCT) through a prospective study enrolling 12 patients with high suspicion of acute myocarditis explored in emergency by MDCT.

Patients and Methods

Subjects

The study cohort comprised 12 consecutive patients (11 men, 1 woman) with a high clinical suspicion of myocarditis based on clinical, electrocardiographic and biological data. Were excluded from the study, patients with history of cardiac infarction or coronary artery disease, having renal failure, known to be allergic to iodinate contrast medium, with arrhythmia or with hemodynamic instability. All patients were assessed by MDCT on emergency. Only three patients were also explored by CMRI with an average delay of 3 days between the two examinations.

MDCT protocol

All the patients in this study were scanned with a multidetector-row CT (64 detectors; LightSpeed, General Electric, Milwaukee, WI, USA) using ECG synchronized tube modulation. The protocol included two stages. A first retrospective acquisition following an intravenous injection of 75mL of non-ionic iodinated contrast medium, Iopromide (Ultravist 370 Bayer Schering, Germany) at a rate of 6ml/sec pushed by 50ml of saline solution and was controlled with a bolus-tracking technique. Scanning started automatically with a delay of 5 seconds after a predefined threshold of 140 HU was reached in the ascending aorta. Scanning was performed from the tracheal bifurcation to the diaphragm using the following parameters: section collimation, 64X0.6 mm; gantry rotation time, 330 msec; pitch adjusted to heart rate; tube potential, 100 kV; and 150-650

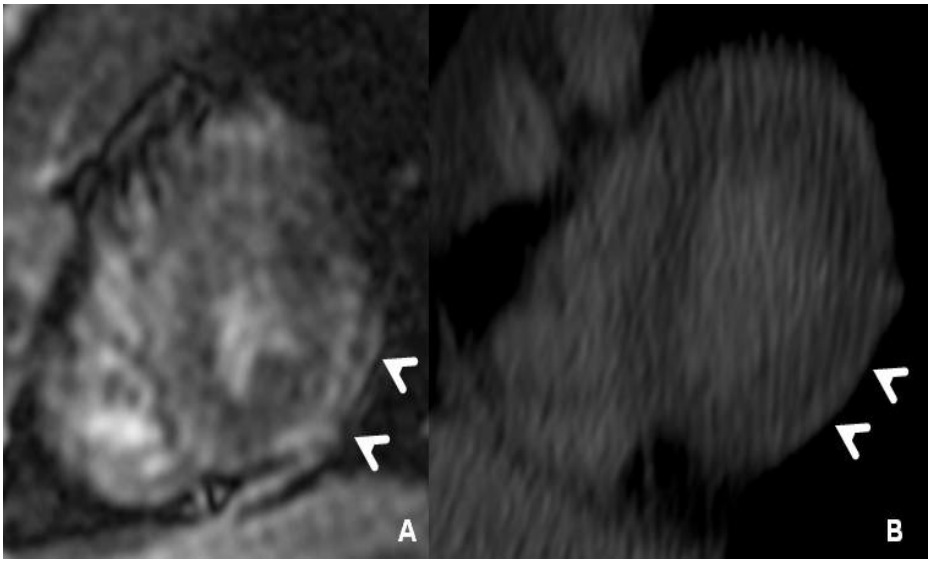

Figure2. Acute myocarditis predominating at an inferior and lateral location: Short axis images from multidetector computed tomography (MDCT) (A) and magnetic resonance imaging (MRI) (B) obtained close to the same level show similar subepicardial enhancement (arrowheads).

mA with ECG dose modulation. The reconstructed field of view was individually adjusted to encompass the heart (mean field of view, 148 mm; image matrix, 512 X 512 pixels). Intravenous or oral beta blockers premedication was given if heart rate was up 65 beat per minute. A second delayed prospective acquisition was done 5 min later without any additional injection of contrast medium at low X-ray dose (80KV, 600 mA).

Image analysis

Cardiac MDCT images assessment was performed on workstation (Advantage windows 4.4; GE healthcare). Coronary arteries were evaluated with maximum-intensity-projection (MIP) and multiplanar curved images for each main coronary artery (> 1.5 mm in diameter) using the first pass acquisition (arterial phase). Image reconstructions were retrospectively made at the diastolic phase (at 60%, 70% and 75% of the start of RR interval). Variations of myocardial enhancement were assessed visually for the delayed prospective acquisition using multiplanar reconstructed images, with a slice width of 5 mm on long axis, four chamber and short axis views.

Results

Characteristics of Population

The study cohort comprised of 12 consecutive patients (11 men, 1 woman). Their age was 28±5 years. The patients had no cardiovascular risk factors except light smoking for 4 patients. Seven patients reported a previous viral infectious episode during the two weeks prior to the onset of symptom. Clinical examination noted febricula in 10 cases. They all suffered from an acute chest pain mimicking angina explored less than 5 days after onset of symptoms. ECG showed ST segment elevation in all cases. Elevated troponin and C-reactive protein levels were noted in all cases.

CT Examination

No complication happened during CT examination which lasted for about 10 min. In all cases, the first retrospective ECG -gated enhanced contrast acquisition allowed a reliable study of coronary arteries and permitted to eliminate a coronary artery disease showing a normal coronary artery system (Figure 1A). The arterial acquisition showed neither pulmonary artery embolism nor thoracic aortic dissection which could have explained the acute coronary syndrome. There was no pericardial effusion too. The second low dose acquisition showed a delayed subepicardial enhancement in 9 cases interesting the infero-lateral walls of the left ventricle (LV) (Figure 1B, 1C, 1D). This delayed hyperenhancement was confirmed in the 3 cases where CMRI was performed with concordant topographic match between the 2 techniques. (Figure 2). For the remaining 3 cases, myocardium had normal attenuation and revealed a homogenous enhancement in both early and delayed phase. Diagnosis of acute myocarditis was supported in all

cases by 1) ruling out an ischemic cause by showing the absence of significant artery lesion of the coronary system and the absence of localized hypoenhancement of myocardium especially in endocardium, 2) Ruling out other causes of ACS such as pulmonary artery, embolism and thoracic aortic dissection, and 3) revealing myocardium necrosis or injury due to an inflammatory process as proved by the delayed hyperenhancement of subepicardium. In case of the absence of a delayed hyperenhancement of the subepicardium, diagnosis of myocarditis was considered on the highly clinical and biological suspicion of myocarditis (young patient with no cardiac risk factors, fever, elevated level of C-reactive protein) and on the absence of coronary artery disease as proved by MDCT.

Discussion

With the generally used clinical criteria only, myocarditis is probably under-diagnosed. CMRI has emerged as a non-invasive powerful tool in the diagnosis and assessment of myocarditis (4). On CMRI, late gadolinium enhancement (LGE) with an intramyocardial to subepicardial accentuated pattern is considered to be highly suggestive of myocardial inflammation (3,5,6). As CMRI is unavailable in our institution, in the context of emergency, for patients with high suspicion of acute myocarditis we practice ECG gated enhanced MDCT trying to study at the same exam first the coronary arteries and then the myocardium. By using a low dose prospective acquisition to study myocardium delayed hyperenhacement, some authors proved the usefulness of MDCT to diagnose myocarditis in comparison to CMRI. (7-10). Two reports of a single patient each are of particular interest (7,8). They both had high suspicion of myocarditis and the investigation using MDCT and CMRI, confirmed the diagnosis of myocarditis and showed an excellent topographic match between the 2 techniques (7,8). The diagnostic value of ECG-gated MDCT to CMRI was also evaluated in 12 patients with high suspicion of acute myocarditis (9). The extent and location of hyperenhancement observed at CMRI and MDCT correlated well. Additionally, the accuracy of delayed enhanced MDCT for differentiating myocarditis from myocardial infarction, was evaluated in 12 patients with normal X-ray coronary angiography (10). Final diagnosis of myocarditis and myocardial infarction was identical by delayed-enhanced on MDCT and CMRI with a significant agreement for the number of involved segments and transmural extension.

The mechanism of late enhancement on CMRI relies on two facts. Firstly, gadolinium chelates are extracellular contrast agents that are inert and cannot cross cell membranes (11,12). Secondly, normal myocytes are densely packed and thus myocyte intracellular space forms the majority (~85%) of the volume and only little interstitial space is available (13,14). In acute myocarditis, myocyte necrosis and thus membrane rupture, allows additional gadolinium to diffuse into what previously intracellular space was increasing its volume of distribution. This in turn results in increased gadolinium concentration and therefore late gadolinium enhancement (15,16). Despite different molecular structures, the molecular weight and extracellular volume of distribution of iodated contrast agents and gadolinium chelates are almost identical. Therefore, MDCT can characterize myocarditis with contrast patterns similar to those obtained by CMRI (17). Late enhancement is not specific for myocarditis and can be seen in multiple diseases (myocardiac infarction, dilated cardiomyopathy, and sarcoidosis). Some features, however, can be considered on account of myocarditis. First, the subendocardium typically is not involved, clearly distinguishing this injury pattern from ischemia-mediated injury (4). This can be explained by the rich epicardial vascularisation and the greater susceptibility of the endocardium to ischemia since heart vascularisation is of terminal type and, as predicted by the wavefront theory, scar formation always includes subendocardium and spreads to variable extent from there to epicardium (18,19). Late enhancement in acute myocarditis is typically localized to the subepicardial regions of the LV and can extend to a variable extent through the ventricular wall. Second, the non-systematic area of late enhancement does not correspond to a specific vascular territory (20,21). The second low dose acquisition by revealing hyperenhancement of myocardial wall respecting endocardium confirms therefore the inflammatory origin of the acute coronary syndrome suspected already on clinical history and examination. Low dose allowed a better contrast between involved and normal myocardium and an important dose reduction in comparison with the arterial first acquisition (9). Besides, the first arterial acquisition on MDCT eliminates pulmonary artery embolism, thoracic aortic dissection and coronary stenosis avoiding unnecessary coronary angiography.

MDCT is more available than MRI especially in the context of emergency, CT examination is shorter than MRI (10 min versus 45 min) and cardiac monitoring is easier than in MRI, which is particularly important in the context of emergency. ECG gated enhanced MDCT can decrease the number of unnecessary coronary angiography for patients with high suspicion of myocarditis and so reduce the cost

of hospitalization.

A major limitation of MDCT is the radiation exposure to the patient. The use of lower tube voltages and prospective ECG pulsing have recently led to dose reduction but still the applied doses remain relatively high (22). The small number of our patients is a limitation of our study which could be explained by the strict criteria of inclusion. It is absolutely inappropriate to obtaine MDCT for a patient with cardiac risk factors and suffering from ACS with elevated ST segment and elevated troponin level. There is no time to waist as coronary angiography is essential for both diagnosis and treatment of coronary artery disease. In the present report, we did not use another standard diagnostic technique to validate the accuracy of the CT diagnosis. It could have been useful if we compared the findings with a more accepted standard, such as CMRI (done in only for 3 patients), or the gold standard (myocardial biopsy).

In conclusion, myocarditis is often characterized by an insidious onset and diagnosis on clinical grounds suffers from limited sensitivity and specificity. It can present as an ACS with elevated ST segment and elevated level of troponin mimicking myocardial infarction In the early phase of suspected acute myocarditis in patients with clinical features, electrocardiographic signs, and laboratory findings consistent with the diagnosis and if CMRI is not available, MDCT can be of an important help. It allows a perfect study of coronary arteries thus avoiding an unnecessary coronary angiography and confirms the diagnosis of myocarditis by showing on the second low dose acquisition a delayed hyperenhancemnt of the myocardium predominating in subepicardium.

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