Perfusion Computed Tomography for the Assessment of Myocardial Viability — a Case Series

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ABSTRACT

Myocardial viability plays an important role in preventing the development of left ventricular remodeling following an acute myocardial infarction. A preserved viability in the infarcted area has been demonstrated to be associated with a lower amplitude of the remodeling process, while the extent of the non-viable myocardium is directly correlated with the amplitude of the remodeling process. A number of methods are currently in use for the quantification of the viable myocardium, and some of them are based on the estimation of myocardial perfusion during pharmacologic stress. 64-slice Multi-detector Computed Tomography (MDCT) during vasodilator stress test, associated with CT Coronary Angiography (CCTA) has a high diagnostic accuracy in evaluating myocardial perfusion. In this article, we present a sequence of 3 clinical cases that presented with symptoms of myocardial ischemia, who underwent 64-slice MDCT imaging at rest and during adenosine stress test, in order to assess the extent of the hypoperfused myocardial areas. Coronary artery anatomy and the Coronary Calcium Score was assessed for all 3 patients by performing CT Coronary Angiography. The combination of CT Angiography and adenosine stress CT myocardial perfusion imaging can accurately detect atherosclerotic lesions that cause perfusion abnormalities, compared with the combination of invasive angiography and single-photon emission computed tomography (SPECT).

Keywords: perfusion computed tomography, myocardial viability, ventricular remodeling

INTRODUCTION

Left ventricular remodeling after an acute myocardial infarction is one of the most powerful predictors of long-term patient evolution. In this process of remodeling, an important role is played by myocardial viability, which has been demonstrated to be associated not only with a lower amplitude of the remodeling process, but also with a major regression following revascularization.¹

After an acute myocardial infarction, the identification of stunned myocardium has a major importance, because it represents the area of viable myocardium that can recover its function if a therapeutic intervention is done in order to improve myocardial perfusion, mainly consisting of interventional revascularization. A ne-
crotic myocardium, where there is no evidence of viability, is an inert tissue and it does not respond well to therapeu-
tic measurements. The extent of the viable myocardium at
the periphery of the infarcted area is correlated directly and
negatively with the amplitude of the remodeling process.2,3

A number of methods are proposed for the quantifi-
cation of the viable myocardium, in order to establish
adequate treatment. 64-slice Multi-detector Computed
Tomography (MDCT) during vasodilator stress test, com-
bined with CT Coronary Angiography (CCTA) has a high
diagnostic accuracy in evaluating myocardial perfusion.4–7

The primary aim of the perfusion CT is to detect myo-
cardial ischemia and to identify the patients that would
benefit most — patients with intermediate to high pre-test
probability of coronary artery disease (CAD), patients
with high Calcium Scores, patients with known CAD, and
those with previous myocardial infarction.8,9

Other methods with high sensibility and specificity that
are used for the evaluation of myocardial viability are low-
dose dobutamine stress echocardiography, single photon
emission tomography (SPECT), positron emission tomo-
graph (PET), magnetic resonance imaging (MRI).10–12

CASE SERIES

In this article, we present a sequence of 3 clinical cases that
presented with symptoms of myocardial ischemia, who
underwent 64-slice MDCT imaging, at rest and during
adenosine stress test, in order to assess the extent of the
hypoperfused areas. The coronary artery anatomy and the
Coronary Calcium Score was assessed for all 3 patients, by
performing CT coronary angiography.

The pharmacological stress test was induced by admin-
istering adenosine, a vasodilator agent, which was injected

![FIGURE 1. A – High calcium content in the LAD; B – Severe stenosis in the RCA; C – Partially reversible hypoperfusion in the apical area](image-url)
over a minimum duration of 2–3 minutes with concomitant electrocardiographical monitoring. The rest acquisition was performed after a sufficient time (15–20 minutes) in which the patients were in a relaxed state.

The 64-slice MDCT examination, focused on the coronary arteries, was performed by dynamic administration of 100 ml non-ionic contrast agent (lopamiro 370) followed by 100 ml saline wash, by an antecubital venous line.

**FIGURE 2.** A – Intramuscular trajectory of the left anterior descending artery in the distal segment; B – Hypodense lesion in the subendocardium, that was extended to the anterolateral wall of the LV.

**FIGURE 3.** A – Intramuscular pathway of the LAD at the level of the middle segment; B – Subendocardial hypodense lesion in the anterolateral wall of the LV in the middle segment.
The examination was well tolerated, without any complications.

The CT examination protocol that was used consisted in the positioning of an intravenous catheter, the continuous monitoring of the 12-lead ECG and blood pressure, and also a close monitoring of symptoms and vital signs.

The pharmacological stress test with adenosine induces a coronary steal phenomenon (the normal coronary arteries dilate more than the arteries affected by atherosclerosis), leading to a difference in flow, therefore identifying the underlying perfusion defect in the territory supplied by the diseased coronary artery. Adenosine acts directly on adenosine receptors, leading to coronary vasodilation; it has a rapid onset and a short duration of action. Thus, a continuous infusion is required for the myocardial CT stress perfusion test (CTP), which possesses a good sensitivity and specificity in detecting myocardial perfusion defects. Side effects include reflex tachycardia, and it is contraindicated in patients with asthma, chronic obstructive pulmonary disease and atrioventricular block.

All patients consented to publication of their data and the publication was approved by the Ethics Committee of the center where the examinations were performed. All the examinations were performed in accordance to the principles stated in the Declaration of Helsinki.

The initial results using 64-MDCT have been promising, showing that myocardial CT perfusion protocol has comparable diagnostic characteristics to SPECT MPI in the detection of myocardial perfusion defects. The myocardial CT perfusion protocol allows simultaneous acquisition of coronary anatomy imaging and myocardial perfusion, and a combined CTA/CTP protocol has been shown to have better diagnostic characteristics than CTA alone.

The radiation exposure in such protocols is similar to that of a traditional SPECT MPI examination. These data suggest that myocardial CTP has the potential to become a robust clinical tool for the evaluation of chest pain patients.

The first case is a male patient known with diabetes mellitus, who presented with an acute myocardial infarction at 18 hours from the onset of symptoms. The Coronary Calcium Score was assessed at 645, showing a very high cardiovascular risk (Figure 1, Diagram A). The coronary anatomy imaging described a 40% aorto-ostial stenosis in the Left Main Artery, moderate and severe stenosis in the Left Anterior Descending Artery (LAD) and a severe lesion in the vertical segment of Right Coronary Artery (RCA) (Figure 1, Diagram B). Furthermore, he had an associated left ventricular (LV) aneurism in the apical segment.

The rest phase CT acquisition detected a hypodense lesion in the subendocardium at the apex of the LV, that was shown to be significantly lower during the stress phase acquisition. This lesion was interpreted as a partially reversible hypoperfusion, possibly due to the vasodilator effect of adenosine, which was used as a myocardial stress agent (Figure 1, Diagram C).

The second case is a male patient who presented with atypical angina pectoris. The Coronary Calcium Score was calculated at 0, therefore indicating a low cardiovascular risk.

The coronary anatomy assessment showed an intramural trajectory of the Left Anterior Descending Artery in the distal segment (length of 22 mm) and Intermediate Artery in the distal segment, without any other significant atherosclerotic lesions (Figure 2, Diagram A). The rest phase CT acquisition detected a hypodense lesion in the subendocardium, that was extended to the anterolateral wall of the LV. The hypodensity was absent during the stress phase acquisition, thus indicating that the perfusion defect is reversible (Figure 2, Diagram B).

The third case is a male patient with known arterial hypertension, permanent atrial fibrillation, a positive history of stroke, who presented with an anterior myocardial infarction at more than 48 hours from the onset of symptoms. The coronary anatomy evaluation showed an intramural pathway of the LAD at the level of the middle segment, without any significant atherosclerotic lesions (Figure 3, Diagram A). The CT stress acquisition revealed a subendocardial hypodense lesion in the anterolateral wall of the LV in the middle segment, which had been absent during the rest acquisition (Figure 3, Diagram B).

**DISCUSSIONS**

Computed Tomography is the most frequent investigation used for the evaluation of coronary anatomy and it has been used as a risk stratification tool for the exclusion of CAD. Myocardial stunning occurs in patients with coronary artery disease in situations in which the myocardium is exposed to transient ischemia, such as unstable angina, exercise-induced ischemia, acute myocardial infarction with early reperfusion, open heart surgery, and cardiac transplantation.

The combination of CT angiography and adenosine stress CT myocardial perfusion imaging can accurately detect atherosclerotic lesions that cause perfusion abnormalities, compared with the combination of invasive angiography and single-photon emission computed tomography (SPECT).
Areas with constant hypoattenuation during both phases correspond to irreversible ischaemia. Reversible ischaemia can be suspected if hypoattenuation is present only in the stress phase or if the hypoattenuated area increases significantly.\textsuperscript{18}

In the first case, the presence of ischemia in the anterior wall of the LV was correlated with the presence of a perfusion deficit which was partially reversible during stress acquisition.

In the second and the third cases, the presence of an intramuscular trajectory of the Left Anterior Descending Artery correlated with a reversible perfusion deficit in the antero-lateral wall of the LV.

CT perfusion imaging, when performed with adenosine stress test, can detect subendocardial perfusion deficits. The combination of CT angiography and CT perfusion imaging can detect obstructive atherosclerosis that causes perfusion abnormalities, highly comparable with the combined gold standard of invasive angiography and single-photon emission computed tomography myocardial perfusion imaging.

**CONFLICT OF INTEREST**

Nothing to disclose.

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**REFERENCES**