

Dual-phase computed tomography imaging in acute chest pain: emerging protocols and potential future implications

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This editorial refers to ‘Clinical utility of two-phase computed tomography angiography for the detection of myocardial perfusion defects related to acute coronary syndrome in patients with acute chest pain: a case series’, by E. Vallejo and C. Buelna-Cano. doi:10.1093/ehjcr/ytab139.

Acute chest pain constitutes one of the most common presentations to the Emergency Department. The aetiology of chest pain can range from benign musculoskeletal chest pain to potentially life-threatening emergencies such as an acute coronary syndrome (ACS), aortic dissection (AAS), or pulmonary embolism (PE). The discrimination of patients with acute pathology can be particularly challenging, as these patients typically present with a variety of clinical manifestations. The accurate and rapid diagnosis of patients with an immediate risk of complications is therefore crucial for institution of appropriate acute management. Advances in cardiac computed tomography (CT) imaging have allowed for rapid and accurate non-invasive assessment of a number of cardiac, pulmonary, and vascular pathologies. Despite its high negative predictive power, the utility of cardiac CT is limited by the need for an optimal heart rate, iodinated contrast, and involves radiation exposure. Therefore, protocols which minimise radiation dose exposure while maintaining high diagnostic accuracy are important to ensure safe and effective application of this tool. Increased demand for rapid result imaging in acute chest pain has established the utility of two dual-phase cardiac CT imaging protocols.

In the triple-rule-out CT (TROCT), the coronary arteries, pulmonary arteries, and aorta are interrogated for ACS, PE, and AAS, respectively.¹ TROCT employs a two-phase single acquisition technique whereby undiluted contrast is injected during the first phase to opacify the aorta and coronary arteries followed by

injection of diluted contrast (1:1; contrast to saline) at the same rate to simultaneously opacify the pulmonary arteries. Optimal enhancement is reached at 300 HU in the coronary arteries and >200 HU in the pulmonary arteries. Electrocardiogram (ECG) gating is used in all cases with a β -blocker (if the heart rate is >65 b.p.m.) and sublingual nitroglycerine.¹ Other TROCT protocols include the test bolus technique whereby peak contrast enhancement in the aorta and pulmonary arteries is predetermined before acquisition takes place.² TROCT has a sensitivity of 94%, specificity of 97%, and a negative predictive value approaching 99% in the diagnosis of coronary artery disease which is comparable to dedicated coronary CT imaging.³ TROCT has been shown to be a more cost-effective option compared with invasive coronary angiography and associated with a reduced stay in hospital.⁴

Dual-energy CT (DECT) imaging allows for improved myocardial tissue characterisation through the detection of change in energy-dependent attenuation of tissues when exposed to two different photon-energy levels. DECT uses iodine mapping to reveal myocardial abnormalities compared to the HU attenuation approach in conventional single energy CT imaging.⁵ Apart from using two different energy levels, dual-phase DECT can detect areas of hypoattenuation on the early phase and areas of hyperenhancement on the late phase, similar to other single energy techniques.⁵ DECT has been shown to have 92% sensitivity and 93% specificity for detecting a myocardial perfusion defect seen on SPECT⁶ and a sensitivity of 77% and specificity of 94% when compared to cardiac magnetic resonance imaging (MRI).⁷

Some limitations prevent the widespread and routine use of dual-phase CT imaging protocols for acute chest pain. As highlighted by Vallejo *et al.*,⁸ the mean effective radiation dose in dual-phase imaging is higher relative to a dedicated CT angiogram imaging protocol.

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TROCT includes more of the thorax compared with a dedicated coronary CT angiogram which results in a higher radiation dose.⁹ A meta-analysis which compared TROCT with several other techniques used to evaluate acute chest pain demonstrated a mean increased exposure to radiation by 4.8 mSv and a mean increased contrast dose of 38.0 mL.³ Dual-phase imaging, including TROCT and DECT, also requires longer interpretation times due to the additional images generated by these techniques¹ which translates to increased turnaround times in a busy emergency CT list. Time delays may be further compounded by beta-blockade requirements to optimise heart rates. For example, patients who are hypotensive are not suitable to receive a beta-blocker.¹⁰

Vallejo *et al.*⁸ report the clinical utility of a dual-phase CT protocol which involves a second delayed phase scan 60 s after the early phase scan to enhance myocardial perfusion defects. The six cases featured highlighted a range of patients presenting with acute chest pain where the suspected diagnosis was either ACS, PE, or AAS. A dedicated imaging protocol with or without ECG gating was then implemented according to the suspected diagnosis followed by the second delayed phase scan. In all six cases, the delayed phase images revealed hypoattenuation in the myocardium suggestive of significant coronary artery disease, which would have been otherwise missed. Retrospective review of early phase images in all cases revealed hypoattenuation in only one case (Case 5). Except for Case 6, all myocardial perfusion defects were subsequently directly or indirectly confirmed on invasive angiography, MRI, and/or SPECT imaging.

Hypoattenuation of the myocardium and its correlation with perfusion defects has been shown to be a good indicator of the myocardial blood pool at the time of the scan.¹¹ Koyama *et al.*¹² demonstrated that early perfusion defects can be corroborated with a decrease in blood volume and myocardial blood flow. The myocardial segments with reduced blood supply will have diminished contrast material and in turn, are visualised as hypoattenuating segments. Comparably, these hypoattenuating regions are shown to correspond to areas of hyper-attenuation seen on CT ~5–10 min after contrast injection due to accumulation of contrast material in the extracellular space when the cardiomyocytes are destroyed in infarction.^{11,12}

The authors' approach of an additional 60 s delayed scan taken after the first initial phase utilises the kinetics of the iodine contrast to improve the visualisation of areas of hypoattenuation. Despite the limitations, this technique is a simple, practical, and a cost-effective measure which may potentially improve the sensitivity and specificity of cardiac CT imaging for detection of significant coronary artery disease in the setting of a busy emergency department. The case series by Vallejo *et al.*⁸ highlights the need for further larger-scale studies into the feasibility of employing such protocols in routine clinical care while taking into account cost, clinical outcomes, and dose-reduction techniques.

Lead author biography



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