

# Cardiac CTA in the Emergency Department

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## Abstract

The assessment of patients with acute chest pain, who present at the emergency department based on clinical history, electrocardiogram results and cardiac biomarkers enables early risk stratification. However, it does not take recognize patients who can be discharged safely without further observation thereby saving time and resources. Alternatively patients with acute chest pain, that have a high probability of acute myocardial infarction benefit from immediate intervention. Here we would like to discuss the benefits of cardiac computed tomography angiography in patients who present at the emergency department with acute chest pain with possibility of acute coronary syndrome.

**Keywords:** Acute chest pain; Acute coronary syndrome; Cardiac computed tomography angiography; Coronary risk stratification

## Introduction

One of the most challenging dilemmas in the emergency department (ED) is the ability to effectively evaluate patients with acute chest pain. Triage of patients with acute chest pain is essential. The aim is to identify patients with very low risk who can then be discharged safely immediately. All patients who present at the ED with chest pain or other symptoms with possibility of acute coronary syndrome must be placed under high-priority triage case. The protocol for diagnosing patients with acute chest pain varies in different countries and hospitals. These patients may be seen by the emergency department physician, cardiologist, general surgeons or medical officers. It is the responsibility of the attending clinician to accurately diagnose the cause of the acute chest pain. Diseases of the heart, aorta, lungs, pleura, mediastinum, oesophagus, stomach and abdominal viscera can cause acute chest pain. It is crucial that the clinician immediately recognizes and excludes life-threatening causes of chest pain such as acute coronary syndrome (ACS).

## Clinical Diagnosis of Acute Coronary Syndrome

ACS is used for patients who have evidence of myocardial ischemia or infarction. ACS consists of ST segment elevation myocardial infarction (STEMI), non-ST segment elevation myocardial infarction (NSTEMI), and unstable angina (UA). STEMI and NSTEMI are defined as presence of myocardial necrosis as evident by a typical rise and/or fall in serum troponin [1]. UA is chest pain syndrome due to myocardial ischemia without myocardial necrosis. Hence the biomarkers are not elevated and clinical diagnosis is based on history, electrocardiogram (ECG) or inducible ischemia on stress testing [2]. The pathophysiology of acute coronary syndrome is secondary to decreased myocardial perfusion due to occlusion of one or more coronary artery(ies), causing reduction in oxygen supply to the myocardium.

The initial diagnosis in suspected ACS consists of a detailed history, 12-lead ECG findings and cardiac biomarkers. Usually a 12-hour monitoring of ECG and cardiac biomarkers are required before safely ruling out ACS.

A detailed history includes pattern recognition of pain and risk factors. Atypical presentation may be seen in females, diabetics and the elderly. 12-lead ECG is crucial in making ACS diagnosis. Some diseases such as ST segment elevation myocardial infarction, dysrhythmia, pulmonary embolism and acute pericarditis may have specific ECG findings.

Cardiac troponin is a specific marker of cardiomyocyte injury

and plays a crucial role not only in the diagnosis of ACS but also in differentiating NSTEMI from UA [3]. The European Society of Cardiology and the American College of Cardiology Committee together redefined myocardial infarction (MI) by an elevation of cardiac troponin T (cTnT) or I (cTnI) in conjunction with clinical evidence of myocardial ischemia in the year 2000. Since then troponin T and troponin I have been used as the biochemical markers in the diagnosis of MI instead of creatine kinase-MB (CK-MB) [4]. Troponin is located on the myofibrillar thin (actin) filament of cardiac and skeletal muscles and encompasses three subunits – troponin I, troponin T and troponin C. Troponin I and T are only found in cardiac muscle, thus they are more specific for myocardial injury and due to their sensitivity may be increased even when CK-MB are normal [5]. Troponin T and troponin I usually elevates within 6 hours of myocardial injury and peaks at 12 hours. It tends to remain elevated for 7 to 10 days following myocardial injury. Troponin however can be elevated in other conditions such as renal impairment and pulmonary embolism/hypertension.

A chest radiograph may be performed in patients of suspected ACS mainly to rule out aortic dissection, pulmonary embolism or acute pericardial disease.

## Role of Cardiac CT Angiography

Risk assessment or stratification depends on findings from history, physical examination, ECG and cardiac biomarkers. Sometimes even clinical history and/or cardiovascular risk factors/scores do not permit a safe initial triage. This is where the role of cardiac computed tomography angiography (CTA) comes into play. The negative predictive value of coronary CTA is 99-100%, based on this coronary CTA is recommended for patients with either a low to intermediate probability of CAD or an inconclusive functional test [6].

Based on observational data between 2006 and 2012, the conclusion from these studies showed that absence of plaque on CTA dismisses ACS with a sensitivity of 100%, while obstructive coronary artery

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disease (CAD) with more than 50% stenosis with a sensitivity of 77% does not. However only 50% of those with obstructive coronary disease on CTA have acute coronary disease [7].

Calcium scoring in acute chest pain is debatable. Although a calcium score of 0 in low risk patients implies a low probability of ACS, it is generally not seen as reliable to rule out ACS in patients with acute chest pain [8]. CT calcium scoring is a non-contrast, non-invasive, relatively low radiation (approximately 1mSv) method where coronary artery calcium (CAC) is quantified. CAC is defined as presence of hyperattenuating lesion in at least three contiguous pixels with a CT density equal to or more than 130 Hounsfield units [9]. The calcium score is a total of the CAC measured for all major coronary arteries and is reported with a reference range based on the age and sex of the patient. CT calcium scoring scan can be used as a filter scan to CTA to detect the severity of calcified lesions. As a high calcium score might affect the diagnostic accuracy and sensitivity, CTA might not be proceeded with in these patients. Depending on the center, the cut-off value can range from 400 – 1000 HU of calcium (Figure 1).

Cardiac CTA can be used for functional and perfusion imaging, however when used in the emergency setting the main focus is on the visualization of the coronary arteries. One of the unique features of CTA is the ability to visualize and characterize coronary atherosclerotic plaque in both obstructive and non-obstructive lesions.

Contraindications to Cardiac CTA include patients with atrial fibrillation or frequent premature ventricular or atrial contractions, those who unable to hold their breath for 10 seconds or unable to follow instructions, known allergy to intravenous contrast and Glomerular Filtration Rate less than 30.

Multiple steps needs to be taken to ensure high-quality images for the diagnostic evaluation of the coronary arteries. These steps include patient preparation and dedicated coronary CTA protocol synchronized with ECG allowing reconstruction of reconstruction of ECG-gated images. The preliminary reviews will be focused on patient's body mass index (BMI), renal function, allergy history, heart rate and vein site for intravenous contrast delivery. The BMI is required for selection of scan parameters, heart rate for image quality, while renal function, allergy history and venous access will factor for contrast medium delivery and prevention of adverse events.

Image quality is remarkably improved in patients with heart rate less than 65 bpm. It has been seen that heart rates decreases by at least

6 bpm during inspiration breath hold. Higher heart rates contribute to motion artifacts causing degradation of image quality. Hence it is advised to reduce patient's heart rate before a scan. Beta-blockers can be administered intravenously or orally for an optimal heart rate unless contra-indicated eg sinus bradycardia, AV block, active or uncontrolled asthma, severe COPD, hypotension, acute congestive cardiac failure, recent cocaine use. A commonly used regimen in current practice is the administration of oral beta-blockers. Fast-acting oral beta-blockers with a short half-life such as oral metoprolol can be given at least 1 hour prior to the examination. An initial dose of 50 – 100 mg can be given with additional doses up to 200 mg overall if an ideal heart rate is not achieved. For intravenous metoprolol, an initial dose of 5 mg with additional doses up to 20 mg may be administered in the CT suite, as effects usually occur in 5-10 minutes. In patients with contraindication to beta-blockers, calcium channel blockers or diltiazem may be used. Vital signs of patients administered with intravenous beta-blockers must be carefully monitored and the staff monitoring these patients must be trained in cardiac resuscitation.

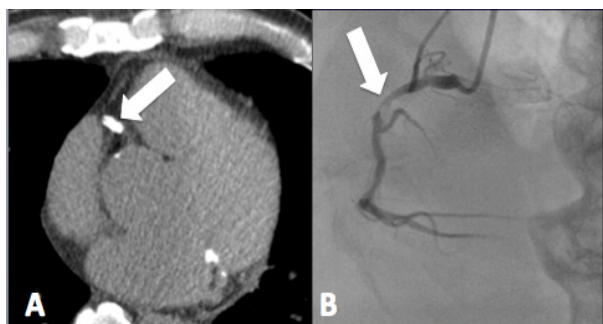
Vasodilation of the coronary arteries can be obtained by administering sublingual tablet or spray of nitroglycerin within four (4) minutes of the scan. Sublingual nitroglycerin not only improves coronary artery diameter but also the image quality and diagnostic accuracy of cardiac CTA without causing any major side effects of systemic physiological changes [10].

Contraindications of nitroglycerin administration include recent phosphodiesterase inhibitor therapy (used for erectile dysfunction or pulmonary hypertension), hypotension and severe aortic stenosis. The most common approach is 400-800 µg of sublingual nitroglycerin administered as either sublingual tablets or a metered lingual spray (1-2 tablets or 1-2 sprays) prior to the CCTA.

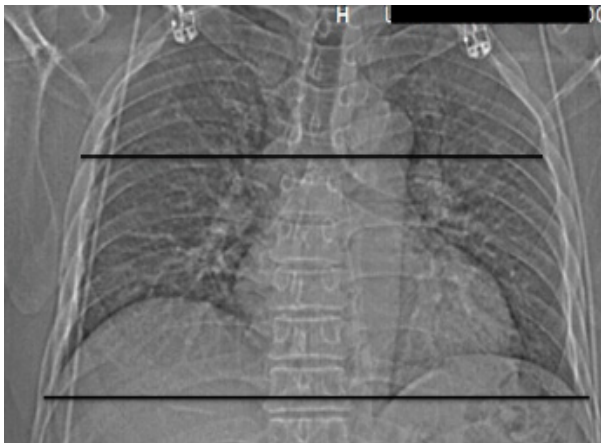
Patients should be nil by mouth at least four hours prior to the examination except for medications. An 18G right antecubital fossa intravenous access must be available to ensure smooth injection of contrast agent at a flow rate of 4-6 mL/s. Cardiac CTA should not be performed until the serum creatinine result is available. It is essential to prepare the patients for the warm sensation of the contrast and to perform repeated breath hold tests.

Cardiac CTA studies for diagnosing coronary artery disease have a dedicated protocol for imaging the heart and coronary arteries. An initial topogram scan (Figure 2) is performed to allow accurate positioning of the scan length. The scan length is tailored to region of the heart. The scan begins just above the origin of the coronary arteries and ends at the hemi-diaphragm. The field of view (FOV) is reduced to the heart region in order to optimize the spatial resolution. The scan is obtained in a single breath-hold, which begins with the injection of a non-ionic contrast with a high concentration of iodine (usually 300-400 mg/mL) at a high flow rate. Depending on the suspected clinical diagnosis a triple rule-out (TRO) cardiac CTA protocol can be performed, which allows the evaluation of the coronary arteries, aorta, pulmonary arteries and adjacent intrathoracic structures. However, this is associated with a higher radiation exposure because of the wider FOV and longer scan time (Figure 2).

In the past, 64-slice multi-detector computed tomography have become established non-invasive diagnostic tools for evaluation of CAD. However with a dramatic advancement in multi-detector technology 128-slice CT and 256-slice CT are currently now available. As the number of CT slice increases, the radiation dose decreases (Table 1).



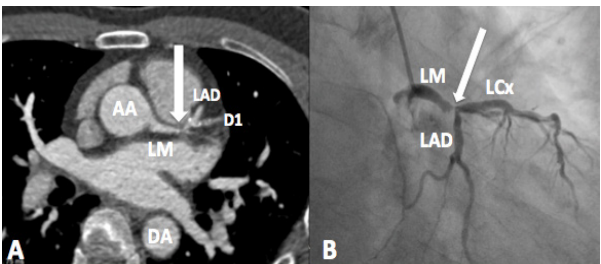
**Figure 1:** 65 year old man came to ED with complaint of acute chest pain. He was diagnosed as unstable angina at ED. As the non-contrasted cardiac CT revealed a total calcium score of 800HU a conventional angiography was done for this patient instead of cardiac CTA. **A:** Large plaque burden in proximal RCA on non-contrasted CT Scan. **B:** Significant stenosis in corresponding proximal RCA on conventional angiography.



**Figure 2:** An initial topogram is done to plan the study. The scan range extends from below the carina to below the level of the heart.

Type of CT Scanner	Approximate radiation dose
64 slice CT	10-15 mSv
128 slice CT	5-10 mSv
256 slice CT	1- 5 mSv
Single view chest radiograph	0.02 mSV

**Table 1:** Radiation dose exposure of various CT Scanner for cardiac CTA.



**Note:** LM: Left main coronary artery, LAD: Left anterior descending artery, LCx: Left circumflex artery, D1: diagonal artery, AA: ascending aorta, DA: descending aorta.

**Figure 3:** Obstructive coronary disease. 55-year-old man presented to ED with episodes of acute chest pain. There were non-specific ST segment changes on electrocardiogram and normal initial cardiac biomarkers. (A) Cardiac CT showed short, severe stenosis in distal LM (arrow) and atherosclerotic plaque in LAD and D1. (B) Conventional angiography confirmed the stenosis (arrow) in the distal LM. Second cardiac biomarkers were positive.

Coronary CTA is performed by continuous acquisition of data throughout the cardiac cycle. The coronary arteries are best visualized in mid-diastole, which is at 60-70% of the R-R interval as they are free of motion artifacts. Retrospective ECG-gated reconstruction allows datasets at various points of the R-R cycle (Figure 3).

Conclusion

Some centers are not keen on cardiac CTAs as they are anatomical

and not functional studies. Moreover lesions identified will lead to more diagnostic tests and cardiac CTA identified CAD leads to more coronary catheterizations. However excluding ACS in an expeditious manner is of high priority as it has been seen that early intervention leads to better outcome. As for patients without ACS or those of low to intermediate risk of ACS, it is essential that time and resources be saved. In addition to being a non-invasive method, advantages include high spatial resolution and relatively low cost when compared with other advanced cardiovascular modalities. Cardiac CTA is useful in the emergency department as it allows early discharge of low to intermediate risk patients with possible ACS, who present with acute chest pain to the ED. In fact low-risk patients can be discharged home without any further evaluation or observation and asked to come back on a regular clinic day. Furthermore, evaluation of patients with cardiac CTA can reduce the length of stay in the ED when compared with standard ED evaluation without an increase in cardiovascular events.

References

1. Amsterdam EA, Wenger NK, Brindis RG, Casey DE Jr, Ganiats TG, et al. (2014) 2014 AHA/ACC Guideline for the management of patients with non-ST-elevation acute coronary syndromes: executive summary: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. *Circulation* 130: 2354-2394.
2. Kumar A, Cannon CP (2009) Acute Coronary Syndromes: Diagnosis and Management, Part I. *Mayo Clin Proc* 84: 917-938.
3. Roffi M, Patrono C, Collet JP, Mueller C, Valgimigli M, et al. (2016) 2015 ESC Guidelines for the management of acute coronary syndromes in patients presenting without persistent ST-segment elevation: Task Force for the Management of Acute Coronary Syndromes in Patients Presenting without Persistent ST-Segment Elevation of the European Society of Cardiology (ESC). *Eur Heart J* 37: 267-315.
4. Alpert JS, Thygesen K, Antman E, Bassand JP (2000) Myocardial infarction redefined—a consensus document of the Joint European Society of Cardiology/American College of Cardiology committee for the redefinition of myocardial infarction. *J Am Coll Cardiol* 36: 959-969.
5. Korff S, Katus HA, Giannitsis E (2006) Differential diagnosis of elevated troponins. *Heart* 92: 987-993.
6. Task Force Members, Montalescot G, Sechtem U, Achenbach S, Andreotti F (2013) 2013 ESC guidelines on the management of stable coronary artery disease: the Task Force on the management of stable coronary artery disease of the European Society of Cardiology. *Eur Heart J* 34: 2949–3003.
7. Nieman K, Hoffmann U (2015) Cardiac computed tomography in patients with acute chest pain. *Eur Heart J* 36: 906-914.
8. Dedic A, Ten Kate GJ, Neefjes LA, Rossi A, Dharampal A, et al. (2013) Coronary CT angiography outperforms calcium imaging in the triage of acute coronary syndrome. *Int J Cardiol* 167: 1597–1602.
9. Budoff MJ, Achenbach S, Blumenthal RS, Carr JJ, Goldin JG, et al. (2006) Assessment of coronary artery disease by cardiac computed tomography: a scientific statement from the American Heart Association Committee on Cardiovascular Imaging and Intervention, Council on Cardiovascular Radiology and Intervention, and Committee on Cardiac Imaging, Council on Clinical Cardiology. *Circulation* 114: 1761–1791.
10. Takx RAP, Suchá D, Park J, Leiner T, Hoffmann U (2015) Sublingual Nitroglycerin. Administration in Coronary Computed Tomography Angiography: a Systematic Review. *Eur Radiol* 25: 3536-3542.