Coronary artery CT in the emergency department

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Background
Chest pain is an extremely common symptom and results in around 700,000 (5%) presentations to the emergency department (ED) in England and Wales and accounts for 25% of hospital admissions. However, only a minority of these patients (8%) actually have acute coronary syndrome (ACS), which is the umbrella term for acute chest pain due to underlying coronary artery disease (CAD).1 The early triage of patients with acute chest pain is clearly imperative to reduce unnecessary hospital admissions and to identify patients who would benefit from early revascularisation or medical therapy; however this is not an easy task.

We highlight the potential role of coronary artery computed tomography (CTCA) in the assessment of such patients.

Introduction
Patients presenting with ST elevation or dynamic ECG changes are simple to identify and manage accordingly with primary percutaneous intervention (PPCI), thrombolysis or early invasive coronary angiography. However, the difficulty lies in those patients presenting with chest pain who have normal or borderline ECG changes for ischaemia and there is ongoing clinical suspicion of underlying CAD. Conventional management in this group of patients necessitates admission to hospital with serial ECG monitoring and biochemical studies, in particular serum troponin, often followed by further investigations such as stress testing.3 Despite this management, there remains a high rate of missed ACS diagnoses, quoted in the literature as being up to 5% in the USA.3

With the advent of new generation CT scanners (>64 slices), CTCA studies can be performed more accurately and with lower radiation dose on those patients who traditionally were more difficult to image, such as those with a high BMI, higher heart rates (>65bpm) and high levels of coronary artery calcification. CTCA has a high sensitivity of >96% in identifying significant coronary artery stenosis. Its major advantage lies in its strong negative predictive value of 98% which can effectively exclude the presence of CAD or significant stenosis, providing a quick and relatively accessible method in the assessment of ACS in comparison to conventional diagnostic investigations, such as invasive coronary angiogram or stress echocardiography.4

There have been several trials conducted internationally that have assessed the impact of early CTCA in the management of those low-to-intermediate risk patients presenting with acute chest pain. These studies have shown that CTCA can be used as an effective tool to identify those patients who can be safely discharged, negating the requirement for hospital admission via the conventional pathway of care. The use of CTCA is supported by the Society of Cardiovascular Computed Tomography (SCCT) to exclude ACS in this group of patients and clearly offers a promising role in lifting some financial burden on the NHS in these times of austerity. However, using CTCA in the acute setting is not currently routine practice in the NHS and a 30-centre national study is underway to evaluate the role of early CTCA in the assessment of ACS.

A further advantage of employing CT in the acute setting is the ability to exclude other potentially life-threatening conditions – the so-called ‘triple rule out’ scan. This uses a slightly different technique which includes assessment of the coronary arteries, but also assesses the pulmonary arteries and thoracic aorta for the presence of pulmonary emboli or acute aortic syndrome.

A negative CTCA therefore clearly has the potential to provide a means of reducing time to discharge in a safe and economically favourable manner. However, if there is a high prevalence of underlying CAD in the population, the use of CTCA in the acute setting will often be positive for non-obstructive disease and result in further downstream investigations such as invasive coronary angiography or fractional flow reserve measurements, which may or may not be of prognostic benefit. Some cases may even result in unnecessary revascularisation or medical therapy.

We highlight the potential role of coronary artery computed tomography (CTCA) in the assessment of such patients.

Technique for performing an acute CTCA is the same as in the elective setting, however patients are more likely to have an elevated heart rate. Patients undergoing a CTCA are screened to exclude a history of severe allergic reaction to an iodinated contrast or of impaired renal function (eGFR >30). To ensure diagnostic image quality, patients will ideally be in sinus rhythm with a targeted heart rate of <65 beats per minute (bpm). In our institution, patients receive an intravenous short-acting beta blocker (eg 10-40mg of metoprolol) immediately before the test to achieve an acquisition heart rate of 55-60bpm, unless there is a contra-indication to beta blockers such as severe asthma, aortic stenosis, atrioventricular heart block or congestive heart failure.

Acquisition
Acquisition technique is dependent on several factors: Heart rate, BMI, level of coronary artery calcification and other factors such as the presence of coronary artery bypass grafts or coronary stents. Image quality is also dependent upon a patient’s ability to lie flat and breath-hold.

Coronary calcium score
All patients excluding those with previous coronary stents or bypass grafts typically will undergo a non-enhanced CT
scan for cardiac calcium scoring (CCS), which provides a means of risk assessment for the presence of CAD. In the current NICE guidelines, patients with CCS zero are considered CAD-negative, however, there remains a small risk (dependent on population characteristics and age) of significant CAD in around 2%. Patients with severe coronary calcification (CCS >400 Agatston U) are conventionally considered unsuitable for CCTA as this often results in non-diagnostic scans and are referred directly for invasive coronary angiography. The advent of newer scanners means that these patients can still be imaged; for example in our institution we would still proceed to a CTCA in the presence of severe levels of coronary artery calcification by scanning in high definition mode, providing the BMI is <30 and in sinus rhythm. It is the combination of adverse patient factors that can limit diagnostic quality.

CT coronary angiography

ECG gating is a crucial component of CTCA technique in order to minimise motion artefact of the coronary vasculature. Technological advancements have enabled CTCA to be performed incurring much smaller radiation doses, mostly due to employing acquisitions in part, rather than the whole, of the cardiac cycle. A prospective acquisition is the most common acquisition in our institution which involves acquiring images at certain points in the cardiac cycle where the heart is momentarily still, and not exposing the patient to radiation during the rest of the cycle. For heart rates <65bpm, the optimal time for imaging is during end-diastole which is at 75% of the cardiac cycle. As diastole shortens as the heart rate increases, systolic triggering is more beneficial for patients with a heart rate >70bpm, where images acquired at 45% of the cardiac cycle provide a more predictable trigger in this group of patients. There are further methods of ensuring image quality by adding parameters such as padding which increases the length of time either side of the trigger point where the images are acquired, and incurs a mild increase in dose accordingly. More advanced techniques can be employed, such as acquiring data from more than one heart beat to reconstruct the final image. For patients with very high heart rates or heart rate irregularity, retrospective acquisitions are employed, which involves imaging the heart throughout the cardiac cycle and then retrospectively reconstructing images at user-defined cardiac segments.

An example of the parameters of a prospective acquisition in our institution without any adverse patient factors would be: 100mls bolus of IV contrast (Optiray 350, Covidien, mA, USA) administered followed by a 50ml saline bolus; scanning is triggered using SmartPrep upon opacification of the ascending aorta with a seven-second delay. An axial acquisition from the carina to the base of the heart with 0.625mm slice thickness and 0.625mm interval in the form of 3-4 blocks. Exposure factors are based on BMI, for example kV 100mA 360 for a BMI of 25 with a typical DLP of 80-100.

Conclusion

A CTCA-based strategy for assessing low-to-intermediate risk patients presenting with a possible acute coronary syndrome is a promising tool to provide a safe, expedited discharge from the emergency department for many patients who would otherwise be admitted. However, further evaluation of the true short-term implications of providing an acute CTCA service in terms of financial and prognostic benefit are required.

References

6. NICE, 2010. CG95 Chest pain of recent onset: Full guideline. NICE. Available at: http://www.nice.org.uk/
**Figure 1**
Basic coronary anatomy. Image modified from Blausen Medical Communications Inc. Creative Commons Attribution 3.0 licence.

**Figure 2**
This unenhanced calcium score scan demonstrates diffuse coronary artery calcification in the left anterior descending (LAD) artery and the left circumflex artery. The total Agatston score for this patient was 4900 – this was combined with heart rate variability, therefore a further contrast CTCA was not performed and the patient was referred directly for invasive coronary angiography.

**Figure 3**
A CTCA demonstrating mixed morphology plaque in the distal left main stem proximal and mid LAD causing a severe stenosis in the proximal LAD.

**Figure 4**
A CTCA demonstrating a complete lack of contrast opacification in the right coronary artery indicating total occlusion, which was over a long segment in this patient.