BCS Editorial

**Computed tomography coronary angiography (CTCA) in coronary artery disease: Where are we today?**

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**Introduction**

The role of computed tomography coronary angiography (CTCA) in diagnosing or excluding coronary artery disease (CAD) risk scoring and not an exercise tolerance test to exclude angina in patients with no previous history of known CAD.\(^1\) The updated 2016 NICE guidelines is notable for its removal of the pre-test probability model and the use of CTCA as the first line investigation in all patients with typical or atypical anginal symptoms.\(^2\) A 64-slice (or above) CTCA should be offered if clinical assessment indicates typical or atypical angina or a 12 lead resting electrocardiogram (ECG) indicates ST-T changes or Q waves in non-anginal chest pain setting.\(^3\) There has been an increase in the use of CTCA by 268% from 2011-2017 in the United Kingdom, although regional inequalities exists, with Scotland and Northern Ireland showing only modest increases in CTCA utilisation.\(^4\) Despite its wide uptake, CTCA has some important limitations which should be considered. In this article I will briefly discuss the relative benefits and limitations of CTCA (see Table 1).

**Take Home Messages**

- Computed tomography coronary angiography (CTCA) can provide information beyond mere exclusion of obstructive coronary disease; characterisation of atheromatous plaque can help in risk stratification.
- In the ISCHEMIA (initial invasive or conservative strategy for stable coronary disease) trial, after moderate to severe ischemia was diagnosed, CTCA was subsequently performed to rule out left main disease and non-obstructive coronary disease.
- By ruling out significant coronary artery stenosis, CTCA potentially has a role in non ST-segment elevation myocardial infarction.
- Although CTCA can initially lead to an increase in invasive coronary angiography, subsequent follow up has shown that there is no significant difference beyond 12 months.
- The results of trials such as DISCHARGE and FORECAST will help clarify the role of CCTA in assessment and management of patients with chest pain and suspected ischemic heart disease.

**Benefits of CTCA**

CTCA can provide information beyond mere exclusion of obstructive CAD. CTCA based atheromatous plaque characterisation helps in risk stratification. Presence of multiple <3mm calcified plaque (‘spotty calcification’) is often associated

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**About the author**

Dr Puskar Bura graduated with MBBS from Kathmandu University in 2011. He is currently a cardiology registrar in Peninsula deanery and plans to sub-specialise in cardiac imaging. He serves as a member of Royal College of Physicians (London) trainees committee and British Medical Association equality, diversity & inclusion advisory group.
with plaque rupture. 

Otsuka et al. asserts that the presence of ‘napkin ring’, characterised by plaque core with low attenuation surrounded by higher attenuated rim-like area is strongly associated with future acute coronary syndrome events.

The recently published ISCHEMIA (Initial invasive or conservative strategy for stable coronary disease) trial concluded that in patients with stable coronary artery disease and moderate or severe ischemia, invasive strategy, as compared to an initial conservative management did not reduce the risk of ischemic cardiovascular events or death over a period of 3.2 years. It is worth noting that in the trial, after patients had stress testing and were confirmed to have at least moderate ischemia, most of the patients (73%) underwent CTCA thereafter to rule out left main coronary disease and non obstructive coronary disease. The debate as to which investigations should be used first in patients suspected of having coronary artery disease is likely to be reignited post ISCHEMIA trial but irrespective of the outcome, one cannot deny the value of CTCA in ruling out both left main coronary disease and non obstructive coronary disease. Furthermore, for the detection of angiographically significant stenosis on invasive coronary angiography (ICA), CTCA has the highest diagnostic accuracy compared with all available noninvasive tests. The criticism of CTCA being just an ‘anatomical’ test can to certain extent be mitigated by the use of fractional flow reserve assessment (CT-FFR), a computer-based technology that produces functional information using computational fluid dynamics in determining functional significance of atherosclerotic plaque.

Relying on CTCA, however, is likely to result in under diagnosis of functional coronary abnormalities like coronary microvascular dysfunction or epicardial coronary spasm which are associated with increased cardiovascular events; these patients may benefit from invasive diagnostic procedures including intra-coronary pressure measurements.

The SCOT-HEART trial demonstrated that the use of CTCA in addition to standard care in patients with stable chest pain was associated with significantly lower rate of death from nonfatal myocardial infarction or coronary heart disease from seventh week onwards once diagnosis were confirmed and medications altered; immediate reductions in events were likely mediated by use of aspirin and revascularisation whilst the longer-term benefits were likely due to statin therapy and lifestyle modifications. Furthermore, the use of cardiac CT for calcium scoring can help to assess prognosis: a zero coronary artery calcification (CAC) score in patients with suspected chronic coronary syndrome (formerly called stable angina) has a high negative predictive value for the exclusion of obstructive CAD and is associated with a good medium-term prognosis.

An observational component of the VERDICT (Very early versus deferred invasive evaluation using computerised tomography) trial assessed the diagnostic accuracy of CTCA to identify coronary stenoses of more than 50% in patients with non-ST-segment elevation myocardial infarction (NSTEMI). The diagnostic performance of CTCA to rule out or rule in significant CAD (equal to or more than 50% coronary stenosis) was high, with a negative predictive value and a positive predictive

<p>| Table 1. The benefits and limitations of CTCA |</p>
<table>
<thead>
<tr>
<th>Benefits</th>
<th>Limitations</th>
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<tbody>
<tr>
<td>Safe &amp; quick procedure</td>
<td>Increase in invasive coronary angiography (initially)</td>
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<tr>
<td>Can be used for plaque characterisation &amp; risk stratification</td>
<td>Image quality affected by various patient factors (i.e. heart rate, arrhythmias, BMI, coronary calcium, inability to hold breath)</td>
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<td>Can reliably rule out obstructive coronary disease or left main stem disease</td>
<td>Radiation exposure</td>
</tr>
<tr>
<td>When combined with CT-FFR can provide functional assessment</td>
<td>‘Anatomical’ test (poor predictor of ischaemia burden)</td>
</tr>
<tr>
<td>Possible prognostic benefit</td>
<td>Diagnostic test only (e.g. inability to intervene on lesions)</td>
</tr>
<tr>
<td>Evolving role in acute coronary syndrome</td>
<td>Risk of incidental findings exposing patients to further investigations (e.g. pulmonary nodules)</td>
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BMI body mass index, CTCA computed tomography coronary angiogram, CT-FFR computed tomography fractional flow reserve.
value of 90.9% and 87.9% respectively. Considering the fact that most patients with false negative CTCA had CAD located in small side branches (luminal diameter of less than 2.5 mm), the negative predictive value of CTCA to exclude clinically significant CAD was 99%; this study suggests that CTCA potentially has a role in a setting of NSTEMI especially when taking into account the fact that up to 20% of patients with NSTEMI have no lesions or non-obstructive lesions of epicardial coronary arteries. Although the study had several limitations such as patient selection (exclusion of patients with impaired renal function, known atrial fibrillation, women below the age of 45 years), its strength lies in the fact that this was a head-to-head comparison between CTCA and ICA assessment. It is worth noting that CTCA strategy in patients requiring subsequent ICA and revascularisation could result in overall higher dose of radiation and contrast volumes; these drawbacks can be mitigated by the use of contemporary CT scanners which are associated with relatively low dose radiation and low contrast volumes.

Limitations of CTCA

There have been concerns that CTCA may increase the use of invasive coronary angiography (ICA). A meta-analysis conducted by Foy et al., comparing the clinical effectiveness of CTCA with functional stress testing observed that CTCA was associated with increased ICA and increased prescribing of aspirin and statins. Based on a criteria of obstructive stenosis of more than 50%, there was an increase in new CAD diagnosis for the CTCA arm with subsequent increase in aspirin and statins prescription; this perhaps led to reduction in myocardial infarction. In another study conducted in Belgium comprising of 113 patients, Devuyst et al. studied the effects of CTCA and functional testing on optimal medical prescriptions in patients suspected of having coronary artery disease; patients underwent either CTCA or cycloergometer and were re-evaluated three weeks later with the alternative test. Devuyst et al. demonstrated that use of CTCA was associated with a 45% increase in statin prescriptions and that patients were five times more likely to be prescribed aspirin. Moreover, CTCA was associated with 3.3 times increase in referral for ICA. Although the sample size was small and it was a single centre study, the strength of this study lies in the fact that all patients had non-invasive testing with cycloergometer as well as CTCA.

The 5 year follow up of the SCOT-HEART (Scottish Computed Tomography of the Heart) study demonstrated that although the rate of ICA and revascularisation was higher in the CTCA group compared to the standard-care group in the initial first few months of follow up, beyond 12 months, the ratio was reversed. This was driven by emergence of unrecognised disease and nonfatal myocardial infarction in standard-care group as well as reduction in disease progression in the CTCA arm due to preventative therapies and lifestyle modifications.

CTCA can often lead to anxiety in patients. In the follow up study of SCOT-HEART trial, Williams et al. concluded that demonstration of absence of coronary heart disease with CTCA and subsequent cancellation of unnecessary anti-anginals and preventative medications led to improvements in symptoms and quality of life; however, demonstration of non-obstructive coronary heart disease only led to increase in significant anxiety symptoms.

Several factors affect the quality of CTCA images: fast heart rate, high body mass index, arrhythmias, ectopic beats and patients’ ability to hold their breath during image acquisition. With a mean radiation dose of a 64 slice CTCA being approximately twice as that of invasive coronary angiography, radiation can be a concern with CTCA.ECG dependent tube current modulation, prospective ECG gating and use of low tube voltage can however all help in reducing radiation burden. NICE recommends the use of newer generation cardiac CT scanners (Aquilion ONE, Brilliance iCT, Discovery CT750 HD and Somatom Definition Flash) as a first-line imaging of coronary arteries in people with suspected stable coronary artery disease in whom imaging with earlier generation CT scanners is difficult; these include high level of coronary calcium (calcium score >400), obesity, arrhythmias, high heart rates that cannot be lowered pharmacologically, previous bypass grafts and stents (19).With varying levels of detector rows, Aquilion ONE (320 X 0.5mm), Brilliance iCT (128 X 0.625mm), Discovery CT750 HD (64 X 0.625mm) and Somatom Definition Flash (64 X 0.6mm), do address drawbacks like spatial resolution, low contrast detection, noise artefacts and higher levels of radiation associated with earlier generation CT scanners.
Upcoming trials

Studies are ongoing to compare the utility of CTCA in patients with stable chest pain compared to ICA. DISCHARGE (Diagnostic imaging strategies for patients with stable chest pain and intermediate risk of coronary artery disease) is a multicentre randomised trial comparing effectiveness of CTCA and ICA in patients with stable chest pain with intermediate pretest probability (10-60%) of coronary artery disease.20 FORECAST (Fractional flow reserve derived from computed tomography coronary angiography in the assessment and management of stable chest pain) is a multicentre randomised trial comparing routine assessment and management of patients presenting with new onset stable chest pain versus FFR-CT.21 This study aims to determine whether routine FFR-CT as a default test is superior in terms of resource utilisation compared to routine clinical pathway recommended by the NICE chest pain of recent onset guidance.

Conclusion

CTCA like any other tests has its strengths and weaknesses. Although the rate of invasive coronary angiography and revascularisation can increase in the first few months after CTCA, subsequent follow up has shown that there is unlikely to be significant differences beyond 12 months. The ISCHEMIA trial, which is likely to reignite the debate regarding the best initial test for suspected coronary disease, has unequivocally demonstrated the value of CTCA in chronic coronary syndrome: ruling out non-obstructive coronary disease and left main coronary disease. Furthermore, with a high negative predictive value and thus ruling out significant coronary stenosis reliably, the role of CTCA in a setting of NSTEMI is evolving. This versatility of CTCA only adds to the argument that CTCA is a friend after all, perhaps even to interventionists.

Disclosures

None.

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