Electron Beam CT Coronary Artery Calcium Scoring For Asymptomatic Coronary Disease

by Dr Duncan Dymond

It is conventional practice to carry out stress testing, with exercise electrocardiography, stress echo or with radionuclide imaging (thallium or MIBI scanning) for the non-invasive assessment of coronary artery disease or for the evaluation of atypical chest pain. These tests rely on the detection of ischaemia, and therefore are only useful when the atherosclerotic process has developed to an advanced stage. A negative test may exclude ischaemia reliably, but is of no use in deciding whether an individual has...
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(continued from front cover)

less advanced disease that has not yet caused significant obstruction of the coronary lumen. It is common practice to advocate exercise stress testing in asymptomatic people for insurance purposes, or as part of ‘well-person screening’, yet an abnormal test in such people is often misleadingly false positive. Further tests, including coronary angiography are often performed to resolve the issue.

Invasive procedures such as angiography or intravascular ultrasound may detect minor disease but for obvious reasons cannot be applied to large numbers of asymptomatic people.

Electron Beam Computerised Tomography (EBCT) is a simple and quick x-ray procedure, which permits the visualisation of coronary artery calcification (CAC) and the early detection of the atherosclerotic process.

The CAC score rises in the population with advancing age, and calcification occurs earlier in males than in females. Individual scores may be compared with an age and gender matched cohort, so any patient can be advised if they are ‘better or worse’ than average. There is a non-linear correlation between the calcium score and the likelihood and severity of underlying coronary obstruction. However, the site of coronary calcification is NOT necessarily the site of an obstructive lesion.

Who should have EBCT and what is done with the results?

In patients with obvious angina, or those who have had a coronary event or revascularisation the test is superfluous except for research purposes. Its major use is to aid in risk stratification in order to identify asymptomatic individuals who are at high risk of coronary disease and to target preventative therapy more efficiently. Numerous prospective studies...
have shown that a high calcium score is associated with a significantly increased evidence of cardiac events. The American Heart Association has recently stated that EBCT CAC scoring provides the gold standard in the risk assessment of individuals considered to be at intermediate risk of CHD according to traditional risk factors.

Advocates of EBCT argue that the avoidance of lifelong statin therapy in those with no coronary calcification could save the NHS large sums of money. Patients with atypical chest pain or those with equivocal exercise tests can be appropriately reassured or referred for angiography depending on the calcium score. Patients with high scores merit perfusion scanning or stress echocardiography, and if there is no inducible ischaemia then only preventative therapy is indicated, whereas angiography is merited if ischaemia is present. Follow up EBCT scanning can be performed to assess the rate of progress of calcium deposition, and aggressive LDL cholesterol lowering is associated with slowing or virtual arrest of such progress.

A high calcium score on its own is NOT an indication for coronary angiography in the asymptomatic person.

Calcium Score and Obstructive Disease

A score of 0 makes the presence of plaque extremely unlikely and is associated with a very low risk of future CVD events (0.05-0.1% a year). A score of below 100 is consistent with a lowish plaque burden, and usually there are no visible coronary stenoses on angiography. A score of between 100 - 400 suggests well-developed plaque but is unlikely to be associated with flow-limiting stenoses. A score of over 400 is more likely to indicate the possibility of higher-grade lesions.

Indications for EBCT Coronary Artery Calcium Scan

1. Risk stratification and guide for treatment decision of asymptomatic males 35 and older and females 40 and over with risk factors for coronary heart disease:
   - Patients with diabetes
   - Elevated cholesterol, hypertension, smoker, obesity, sedentary lifestyle, etc.
   - Family member of patient with premature CAD
   - Systemic disease with potential coronary effects (e.g. SLE, chronic renal disease, HIV)

2. To monitor CAD stabilisation/progression, particularly in patients treated with lipid-lowering drugs.

3. Aid to diagnosis of patient with:
   - Atypical chest pain or symptoms with low to moderate pre-test likelihood of ischemia
   - Patient with equivocal stress test & radionuclide /stress echo result

However, there is marked individual variability and between scores of 400 - >1000 the whole spectrum of obstructive disease may be encountered. Recent studies have examined the relationship between calcium score and inducible ischaemia, using stress echocardiography or perfusion scanning. A consensus has emerged that for those with a score of below one hundred the yield of testing for inducible ischaemia is so low as not to be worthwhile in asymptomatic patients. As the score rises, so does the likelihood of finding inducible ischaemia even in asymptomatic patients.

Limitations of EBCT

Apart from the limited availability of scanners (although the newer generation of 64 multislice CT scanners can do calcium scoring) the major criticism of EBCT is its inability to detect the soft non-calcified plaque. It is these plaques that are the most vulnerable, being more likely to rupture and produce a sudden unheralded thrombotic event and/or sudden death in an asymptomatic person. In practice, in men over the age of 40, soft vulnerable plaques usually co-exist with the hard calcified plaques, which are markers of the inflammatory process. In those under the age of 40 soft plaques may exist on their own. A useful complementary test in such individuals is the detection of carotid artery atheroma by Doppler measurement of intimal-media thickness; the assumption being that any coronary soft plaque will usually be associated with carotid atheroma. The use of EBCT to ‘exclude’ the atherosclerotic process should generally be reserved for those over 40 years of age.

Conclusions

There is now compelling evidence to support EBCT coronary artery calcium measurement as an effective means of screening individuals for CHD. A high score indicates significant atheromatous disease and thus the need for aggressive preventive treatment. Conversely, a zero or low score indicates none or minimal coronary atheroma and thus no need for preventive medication or further testing, regardless of any surrogate risk markers such as diabetes or elevated cholesterol levels.

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Peripheral Angiograms

ESC provides a fast and non-invasive peripheral femoral angiography service, with patients free to resume normal activities that day. The EBCT scanner produces high quality imaging that can accurately detect stenoses in the peripheral arteries and demonstrates the calcified plaque not easily seen on magnetic resonance angiography (MRA). We also provide a dedicated EBCT angiography service for abdominal aneurysm assessment, both pre-operatively for 3D images and measurements prior to endovascular stenting and post operative stent assessment. We have many years of experience in this for local vascular surgeons.

Imaging

- Which scanner for which disease?

Today, more than ever, almost every branch of medical practice relies upon radiological imaging to support initial clinical acumen and provide the diagnostic confirmation to optimise patient management. However, the enormous technological advances in recent years have resulted in rapid changes in availability and types of scanners and ever increasing claims by manufacturers and proponents of their capabilities. Such exaggerated claims are often confusing to both medical practitioners and patients and can lead to inappropriate scanning and the wrong choice of imaging modality. This article summarises the essential features of each of the different scanning modalities.

CT Scanners

Over the last few years multi-detector CT (MDCT) scanners have become commonplace, largely replacing the earlier spiral scanners. MDCT scanners contain multiple rows of detectors (4, 8, 16, 32 or 64) allowing multiples of thin visual slices to be acquired with each rotation of the x-ray emitting gantry. For some applications, e.g. angiography, increasing the number of detectors can lead to improved image quality. However, more is not necessarily better and in inexperienced hands thinner slices can easily result in more background noise and increased radiation to the patient, as more image runs are needed to visualise small lesions in various vascular phases. Indeed, in inexperienced hands, the images from these new scanners can be inferior. The latest electron-beam CT (EBCT) scanner offers many advantages over conventional MDCT scanners. Its design means the source of x-rays is fixed, avoiding the need for a rotating gantry. Image acquisition speed is therefore up to 5-fold faster than even 64 slice MDCTs allowing single heart beat imaging. The superior speed of the EBCT scanner also greatly reduces radiation exposure to patients.

In the right hands, image quality is often superior to even 64 slice MDCT scanners (Fig 1).

MRI

Magnetic resonance imaging (MRI) uses a powerful magnet inside which the patient lies. MRI scanners come in different field strengths, usually between 0.5 and 1.5 tesla. Radio waves 10,000 – 30,000 times stronger than the earth’s magnetic field are then sent through the body. This affects the body’s atoms, forcing the nuclei into a different position. As they move back into place they send out radio waves of their own. The scanner picks up these signals and a computer turns them into a picture, depending on their location and strength. Tissues with few hydrogen atoms (e.g. bone) turn out dark, while tissues with many hydrogen atoms (e.g. fat) look bright. As most diseases manifest themselves by an increase in water content, MRI is a sensitive test for the detection of many diseases. It is also safe as it uses radiation in the radio frequency range, which is all around us.

Fig 1: Chest CT scans (top) and abdominal CT scans (bottom) from an EBCT scanner (left) and a 64 slice MDCT scanner (right)
CT–PET
Positron Emission Tomography (PET) involves the intravenous administration of radioactive tracer, often glucose (fluorodeoxyglucose, FDG). The PET scan shows where the glucose is broken down and as cancer cells use glucose differently this shows up on the scan. FDG PET scanning provides useful information in the detection, staging and therapy monitoring of many tumours, including lung, colorectal, lymphoma, and melanoma. However, its role in many other cancers remains uncertain. The addition of a CT scanner to the PET increases sensitivity and specificity. However, care needs be taken with false positives due to physiological uptake in lymphatic tissue, salivary glands, some muscles and areas of inflammation or infection.

Operators
With the increasing sophistication and diagnostic potential of the different imaging modalities, the expertise of the radiographer and interpreting radiologist becomes crucial in order to deliver the optimum report and correct diagnosis. The increased speed of the latest CT and MRI scanners requires attention to the individual protocol for each patient. Just producing lots of thin slices is not always what is required and the images can be very noisy. An experienced radiographer will adjust the protocol according to the clinical question being asked, such as altering the timing of contrast injection. They will review the images with the patient on the table and perform further scans if necessary, resuture an examination and data in equipment malfunction, and provide a second pair of eyes for the radiologist. The experience of the latter is equally important. Radiologists now tend to be so specialised that it is essential that the correct specialist reports the appropriate images; one would not ask an orthopaedic surgeon to perform a tonsillectomy. This is particularly so in the private sector when radiologists may often be asked to report an entire list which may include areas outside their area of expertise.

Conclusions
The increasing complexity and technological advances of imaging modalities is likely to continue. Clinicians need to know the advantages and disadvantages of each scanner type in order to make the appropriate radiological request and obtain the correct diagnosis. Equally important is their confidence in the expertise of the operator and specialist skills of the reporting radiologist.

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<table>
<thead>
<tr>
<th>CT (MDCT and EBCT)</th>
<th>MRI</th>
<th>CT–PET</th>
<th>Ultrasound</th>
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<tr>
<td>Abdominal and pelvic; lungs; cardiac; urological (largely replaced IVUs); bone trauma; colon; sinuses; vascular; emergency brain scans or brain scans for &quot;headache cause&quot;; guided biopsy and drainage</td>
<td>Brain (superior detail of posterior fossa and brain stem vs CT, epilepsy, white matter disease, pituitary gland, complications of HIV, movement disorders); spine; joints and peripheral soft tissues; body (oncological staging); some angiography; bones (infections and metastases); in the future cardiac function</td>
<td>Staging and follow-up of many malignancies, normally after CT scanning</td>
<td>Solid abdominal organs; gynaecological and obstetric imaging; breast lumps; thyroid and other neck lumps; vascular (carotid Doppler and DVT); testicular; prostate gland; initial musculoskeletal assessment (esp. shoulders and ankles); guided biopsy</td>
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<td>Fast; 'open'; less sensitive to patient movement; quiet</td>
<td>No radiation; non-iodinated contrast (less risk of allergy)</td>
<td>Improved sensitivity and specificity compared to CT or MRI alone for oncological imaging</td>
<td>Good for first radiological assessment e.g. abdominal pain; quick; non-irradiating; non-claustrophobic</td>
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<td>Radiation; risk of contrast reaction</td>
<td>Slow (20–30 mins for abdo scan vs 20–30 secs for CT); often claustrophobic (less so with open or upright scanners); noisy; sensitive to metal implants; sensitive to movement; does not detect calcium; image interpretation more difficult than CT; often detects small 'abnormalities' in the brain of uncertain clinical significance</td>
<td>False positives; not effective in all tumours; requires prolonged patient immobility; expense of scanners and tracer preparation; scarcity of trained staff</td>
<td>Poor spatial resolution; ineffective for gas containing organs (colon, stomach, lungs) and cannot scan through bone (brain); suboptimal for retroperitoneal organs or large patients; very operator dependent; images less easily interpretable by other radiologists/specialists</td>
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Virtual Colonoscopy is the most cost-effective screening technique for Colorectal Cancer

A recent study has found that virtual colonoscopy (VC) is the cheapest and safest way to reduce colon cancer mortality in individuals 50 years and older. Using a minimum 6mm polyp size threshold, VC was more than twice as cost-effective as optical colonoscopy per life year gained, researchers reported in the June edition of Cancer. The researchers also reported that the very low risk of malignancy of colonic polyps smaller than 6mm in size argues against spending money to follow or remove them.

Furthermore, the use of VC rather than conventional colonoscopy reduced the number of invasive endoscopic procedures by 77.6%, which greatly reduced the number of complications of bleeding and perforation related to optical colonoscopy. The authors concluded that the use of primary VC screening as a selective filter for optical colonoscopy polypectomy for lesions 6 mm and larger ‘represents a powerful new approach to (colorectal cancer) screening.’

British Cardiovascular Conference

The European Scanning Centre recently attended the British Cardiovascular Society (BCS) Congress at the SECC in Glasgow. This was the third year we have attended the UK’s leading cardiology conference and we received a great deal of interest. On the European Scanning Centre stand, delegates were given an overview of how EBCT, the fastest and most accurate CT scanner available works to quantify coronary artery calcium deposition and to see for themselves the incredibly detailed 3D images produced.

New Staff

We are delighted to announce the recent appointment of Caroline Metcalf as our Marketing Executive to work alongside Inder Bull. Many of you may have already met Caroline, whose major role is to liaise with our referring clinicians. Our new Marketing Assistant, Amon Woulfe has also joined Caroline in the team to provide additional marketing support. It is always a pleasure to welcome new members to the team and they both look forward to working with you in the forthcoming months.
The ESC is now able to offer state-of-the-art MRI scanning facilities. We have teamed up with a leading open MRI centre near to us. The avoidance of claustrophobia and dynamic nature of the scans means it is extremely suitable for spine and joint imaging. Contact our administration team on 020 7436 5755 for further information or to make a booking.

SPOTLIGHT... on our Radiographers

How long have you both worked at ESC?
Tony 'I have been here since the beginning and helped to start the centre in 2002. Mike 'I then arrived about 6 months after Tony. Tony 'Mike actually used to be my boss at The Middlesex Hospital so we have worked together for quite sometime'.

So it is important to work as a team rather than individuals?
Mike 'Absolutely. I focus on the scanning process and interacting with the patient and Tony works on creating the imaging and reports.' Tony 'It works well as we each focus on our strengths. We are both trained in all areas though, so the process is very efficient.' Mike 'It is also important that we work well with the Radiologists. Two eyes are better than one and you should always be able to critique each other.'

Why do you use an EBCT scanner?
Tony 'We have experience in all forms of imaging modalities and the CT scanner is by far our favourite.' Mike 'I agree. It is very user-friendly and produces high-quality scans and images.' Tony 'The EBCT gives the radiologist the best available image for diagnosis.' Mike 'It is also an open scanner and scans very quickly at a lower than usual x-ray dose, which patients appreciate a lot.'

How challenging is the daily variety of scans?
Mike 'Every scan is different and every patient is an individual. It is very important that a radiographer has the experience and knowledge to be adaptable to a patient.' Tony 'It is about using the radiation dose as efficiently and accurately as possible. The quality of the image is very much down to the experience of the radiographer.'

How important is the role of the radiographer in the diagnostic process?
Tony 'We do the engine room work and the radiologists get the glory.' Mike 'The quality of the images is critical to obtaining the optimum report.'

Describe a patient’s journey through the scanning room?
Mike 'I always think; if I came in for a scan then how would I like to be treated? It is 15 minutes for us, but it is a lifetime for the patient.' Tony 'It is very important to make the patient feel as comfortable as possible.' Mike 'Indeed. Not only do we need to be very good technicians, but very good 'people persons' as well.' Tony 'Our focus is on the whole patient experience, not just the scan, so we aim to treat them with care and respect from the moment they enter till the moment they leave with their report.'

What do you enjoy about working at the ESC?
Tony 'You get to work in a small handpicked team with professionals that you trust. In this profession it is all about the quality of the team you work with.' Mike 'Even though he is the boss now we work very well together as a team and subsequently deliver a high-quality service.'
Ross’s Riddle

In each issue 6 bottles of vintage Champagne will be offered to one lucky reader whose correct entry is drawn at random. Entries to be submitted by Friday 31st August, via email to: caroline.metcalf@europeanscanning.com The answer & name of the winner will be announced in the next edition.

Riddle 1

You have two strings which will burn for one hour each but they burn in an unpredictable way so that you cannot be sure that half the string would burn, say, in half an hour.

Using the strings, how can you time exactly 45 minutes?

Mr CW is a 44 year old sports journalist who is a keen athlete; he runs 3–5 miles every day, plays regular 5–a-side football and has undertaken several marathons.

He recently attended for a routine health medical at which his ECG revealed changes consistent with left ventricular hypertrophy. He was noted to be hypertensive and hyperlipidaemic, both of which were subsequently well controlled on Adalat LA 20mg and simvastatin 20mg, respectively. He was referred to a cardiologist who elicited a history of intermittent vague chest discomfort but which was not related to exertion.

However, he was sent to the ESC for an EBCT coronary artery scan which demonstrated a grossly elevated calcium score of 1205 (> 99th centile; Fig 1), and a subsequent MIBI scan showed an enormous reversible perfusion defect in the anterior myocardium (Fig 2).

Interventional angiography demonstrated a critical stenosis (>95%) at the ostium of the left anterior descending artery with a lesser (70%) stenosis further down the LAD, and additional significant diagonal and right coronary artery disease. A total of 4 drug eluting stents were inserted with excellent reperfusion. Mr CW remains extremely well with complete resolution of his previous symptoms, and has recently completed another marathon.

What’s your view?

We welcome any feedback, questions or queries you may have on any of the information in our quarterly newsletter. Please email your comments to: carolinemetcalf@europeanscanning.com and we will post them in the next issue.