Top 10 interesting facts about our Aquilion ONE CT

ESC achieves highest CQC registration

‘One stop-shop’ introducing Cardiac CT stress perfusion
Welcome to our latest edition of Vision

Cardiac CT perfusion

Dr L Ceri Davies MD FRCP
Consultant Cardiologist, Barts & The London NHS Trust

The last couple of years have seen significant advances in computed tomography (CT) technology – with improvements in both hardware and software. These have resulted in a large increase in cardiac imaging using this technique and in particular CT coronary angiography (CTCA).

The new generation CT scanners (which include the Aquilion ONE) allow coronary artery imaging to occur at a very low radiation dose (significantly less than that of a conventional, invasive coronary angiogram) and several multi-centre studies have shown an extremely high negative predictive value (over 95%) for diagnosing significant coronary artery disease (CAD).

There are, however, several limitations that restrict the utility of CT coronary angiography. The first is that the diagnostic accuracy of CT is reduced by heavy calcification, resulting in an over-estimation of the severity of CAD and false positives when compared to invasive coronary angiography. The second, which is true of all coronary artery imaging techniques including invasive coronary angiography, is that lesions that appear anatomically significant do not necessarily cause ischaemia. There is now compelling data which suggests that, in the context of chronic stable angina, coronary artery lesions should only be revascularised if ischaemia can be demonstrated.

Conventionally, patients who have had CAD diagnosed by angiography need to undergo additional functional examinations such as nuclear stress imaging or cardiac MR to demonstrate that a stenosis is haemodynamically important. This requires an additional study and patient inconvenience, a delay in making a diagnosis and instituting correct therapy and, in the case of nuclear imaging, a high radiation dose (15-20 mSv).

This article will describe the novel technique of CT cardiac perfusion, which when combined with CTCA allows the complete assessment of a patient’s CAD in a single sitting, with a high level of accuracy but low radiation dose.

Principles of pharmacological stress

The commonest pharmacological agent used in perfusion imaging is adenosine. It acts directly on adenosine receptors to cause coronary artery vasodilatation. There is preferential vasodilatation of normal vessels compared to abnormal ones, and as a result, less contrast will be delivered to myocardium subtended by diseased vessels. This can be identified as an area of low attenuation in the subendocardium - a so-called perfusion defect.

Perfusion defects caused by ischaemia, are not present at rest and are identified by comparing stress and resting images. These are termed reversible perfusion defects. Irreversible perfusion defects, occurring both at rest and stress, are caused by infarction.

A typical protocol for combined CTCA and CT perfusion is shown below.

- Normal patient preparation - no caffeine, dipyridamole or aminophylline
- Give β-blocker (to reduce HR <70 bpm for Aquilion ONE) +/− GTN
- Resting CT angiography
- If normal or mild disease – no further scan
- If abnormal (significant calcification, stent, equi-vocal stenosis - 50-70% lumen narrowing) - intravenous adenosine at a rate of 140mcg/kg/min for 3 minutes

Table 1: Comparison of different modalities for assessing functional significance of coronary artery disease

<table>
<thead>
<tr>
<th></th>
<th>CT stress perfusion</th>
<th>Nuclear scan ‘Myoview’</th>
<th>MRI stress perfusion</th>
<th>Stress echocardiogram</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration</td>
<td>30 mins</td>
<td>2 days (2 hours each visit)</td>
<td>60 mins</td>
<td>60 mins</td>
</tr>
<tr>
<td>Option of one stop angiogram + perfusion scan</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Claustrophobia</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Radiation dose</td>
<td>5-6 mSv (includes CTCA scan)</td>
<td>15-20 mSv</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Direct correlation with angiography</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Clinically available objective quantification</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Spatial resolution</td>
<td>0.7 x 0.7 mm</td>
<td>10 x 10 mm</td>
<td>3 x 3 mm</td>
<td>2 x 2 mm</td>
</tr>
<tr>
<td>Sensitivity and Specificity</td>
<td>86-96%</td>
<td>75-100%</td>
<td>81%</td>
<td>65%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>90%</td>
<td>81%</td>
<td>85%</td>
</tr>
</tbody>
</table>

Table 2: Specifications of new generation CT scanners

- Compare myocardial signal from both sets of images.
- The total radiation dose for a combined CTCA and CT perfusion study is the equivalent of slightly more than two CTCA, which for the
Aquilion ONE is generally around 5 mSv (significantly less than the 15-20 mSv from a nuclear scan). Two injections of contrast are also required, giving a total volume of around 120mls. As X-ray contrast will persist in areas of myocardial infarction, it is also possible to detect this by performing a late scan to look for enhancement in a similar manner to late gadolinium enhancement in cardiac MR. This will obviously incur additional radiation dose.

There are a few contraindications to adenosine stress perfusion. They include significant reversible airways disease and high grade AV block. New stressor agents such as the selective A2A receptor, Regadenoson, are better tolerated and can be used in patients with asthma. Patients with contraindications to iodinated contrast e.g. severe allergies or renal impairment are also unable to have CT perfusion.

Overall, CT perfusion offers significant advantages to other current cardiac functional investigations (Table 1).

Published studies
Several pre-clinical studies have assessed the accuracy of CT perfusion in animal models of CAD. The standard comparison has been with microsphere myocardial blood flow (the gold standard), with a strong correlation being shown between the two techniques.

These findings have led on to a number of human studies where CT perfusion has been compared with conventional angiography, nuclear SPECT and cardiac MR perfusion. These studies are generally relatively small and are carried out in single centres. However, in total data from over 250 patients has been published with sensitivities ranging between 86-96%, specificities of 67-100%, negative predictive values of 79-91% and positive predictive values of 79-100%.

The radiation doses have ranged from 2.5 mSv (latest studies with new generation scanners) up to 20 mSv in the very first published studies (64 slice scanners with retrospective gating). Further larger, multi-centre, prospective studies (such as CORE-320) are currently underway.

Requirements for CT cardiac perfusion
There is increasing recognition that CT perfusion can offer a viable alternative to other modalities giving comparable accuracy but with several advantages. As with CTCA, maximising the accuracy requires a combination of latest scanner technology, experienced radiographers and interpretation by practitioners with considerable experience in either CMR or nuclear perfusion. Scanners such as the Aquilion ONE by virtue of its 16cm volume acquisition in the z axis allows imaging of the entire myocardium in one rotation and avoids step artefacts seen with other scanners.

 Artefacts and questions
As with all novel techniques, there are new CT-related artefacts to recognize. The main one of these is beam hardening. This occurs when x-ray beams pass through objects of high density resulting in a hypoenhanced region that may be mistaken for a perfusion defect. Beam hardening artefacts are typically seen in the basal inferolateral wall and appear as a triangular shape, which allows them to be recognised as such by experienced practitioners.

As a relatively new technique, it remains to be determined whether the optimal protocol involves performing the rest scan first before the stress, or following the stress study. The main advantage of performing the rest scan first is that patients without coronary artery disease do not need to go on and have the second stress scan. The disadvantage of performing the rest scan first is that contrast contamination during the stress scan may lead to decreased sensitivity for identifying ischaemia and the use of β blockers and GTN may also result in an under-estimation of ischaemia. These issues can be minimised by waiting 10 minutes between scans to allow the effect of drugs to wear off.

Report format
CT perfusion images can be provided in a number of different formats including axial black/white images for direct viewing of suspicious defects, which most cardiologists are most comfortable with. Computer generated colour images analogous to the nuclear scans can either be pixelated or in the 17 segment view with hypoperfused areas coloured blue. The 3D reconstruction of the entire myocardium is often useful to the patient but less so for the clinician. One unique feature of the CT perfusion is the ability to directly compare with the CTA images and report, thereby allowing a degree of internal control.

Summary
Several studies have shown that CT cardiac perfusion can be performed with good, if not better agreement than other conventional, non-invasive imaging modalities and with several advantages. The radiation dose from perfusion CT is significantly less than nuclear perfusion imaging and the combination with CTCA allows patients with significant CAD and no flow limiting stenoses to be identified.

CT cardiac perfusion can be performed with good, if not better agreement than other conventional, non-invasive imaging modalities and with several advantages’
Top 10 interesting facts about our Aquilion ONE CT

1. We have the ONE and only in UK independent healthcare
   We have the only Aquilion ONE CT - the world's first dynamic volume CT scanner - in the UK independent sector. It is the most advanced CT scanner in the world with technology that improves routine examinations and offers unique advanced functions.

2. We can scan whole organs in ONE
   Using 640 ultra-high resolution 0.5mm ‘slices’ our Aquilion ONE can image 16cm of anatomy in one rotation of the gantry and for the most part without table movement. This 16cm volume coverage means we can image a whole organ such as the heart or brain in a single rotation. In comparison, 64 slice CT scanners produce just a 3.2cm view of a particular organ and require an average of 7-10 overlapping rotations to image the entire heart, and 7 rotations for the whole brain.

3. You are safer with ONE
   Whole organ imaging means fewer rotations and therefore a much lower radiation exposure. Our Aquilion ONE scanner also features a full suite of dose reduction technologies, including Adaptive Iterative Dose Reduction (AIDR) software that limit radiation dose to the lowest possible amounts while maintaining the highest clinically appropriate image quality needed for diagnosis. The numerous advanced dose reduction features of the system help make CT imaging safer for patients. For example the radiation dose for a CT coronary angiogram on our Aquilion ONE machine is 1-2.4 mSv, compared to approximately 4-10 mSv for a typical 64 slice scanner and 8-14 mSv for conventional angiography.

4. Our ONE is quicker
   Our Aquilion ONE can carry out a complete examination in just 0.35 seconds eliminating the need to reconstruct data from several points in time, thereby enhancing accuracy and producing dramatically clearer diagnostic images. 64 slice CT scanners have to ‘stitch together’ a series of individual images, each taken at a different moment in time in order to obtain the final image, frequently resulting in ‘step-artefact’.

5. ONE’s images are clearer
   Our Aquilion ONE has the highest spatial resolution of any CT scanner of 0.3mm; 30% better than the 0.5mm of a typical 64 slice CT.

6. Whole organ perfusion makes our ONE unique
   With the Aquilion ONE we have the only CT scanner able to show arterial and venous blood flow through whole organs, enabling us to study organ function as well as anatomy during the same appointment. Our Aquilion ONE has the ability to acquire and fuse anatomical and perfusion data from the whole heart and brain. Due to the limitations of their detector widths (i.e. 3.2cm for a 64 slice CT scanner) whole brain and whole heart real-time imaging cannot be achieved on any other CT scanner. This reduces their ability to perform CT perfusion and renders 4D dynamic whole heart and brain perfusion impossible.

7. We have the only ONE capable of 4D joint imaging
   With the Aquilion ONE, we have the only current imaging modality (CT or MRI) that shows tissue and bone in real-time motion, such as joints moving or the spine rotating. We can scan painful movements and in specific positions, and with rapid continuous acquisitions made possible with the Aquilion ONE’s 16cm volume coverage, we can produce clinically valuable real-time videos at low radiation dose.
You can save time and money with ONE

Our Aquilion ONE scanner offers a viable alternative to many diagnostic and often invasive investigations. For instance, the typical investigative pathway for patients with suspected coronary artery disease (CAD) usually involves multiple tests (exercise treadmill test +/- nuclear ‘Myoview’ scan +/- invasive angiography). The Aquilion ONE’s unique 16cm volume imaging and complete heart coverage allows a simple one stop shop alternative. Our CT coronary angiogram when combined with our CT cardiac stress perfusion scan replaces all three tests e.g. exercise treadmill test, Myoview perfusion scan, invasive coronary angiography in a single sixty minute visit, saving the patient time, reducing the radiation dose to less than 6 mSv and reducing costs. In comparison, the conventional pathway requires around 4 days for the investigations to be performed, excluding scheduling issues and a radiation dose up to 30 mSv.

ONE offers non-invasive and more accurate alternatives

The superior spatial resolution of our Aquilion ONE CT (which is comparable to invasive coronary angiography) combined with a significantly reduced radiation dose means we can offer a safer, non-invasive alternative to conventional cardiac angiography. In addition to measuring any lumenal stenosis, the Aquilion ONE and its unique software allows us to accurately visualise and quantify the presence of non-calcified soft plaque in the walls of the coronary arteries (therefore those plaques that are potentially vulnerable to rupture): this is not possible with either a 64 slice scanner or conventional invasive angiography.

This ONE is worth it

The Aquilion ONE CT scanner took 7 years and cost more than £500 million to develop and we have invested over £2 million in this dynamic volume CT machine. Weighing in at around 2 tonnes our Aquilion ONE had to be lifted into the clinic through the demolished wall of our scanning room with the aid of a massive crane. Since its installation in December 2009, we have scanned nearly 7,000 patients and have become one of the world’s top 5 centres for CT coronary angiography.

<table>
<thead>
<tr>
<th>Feature</th>
<th>Only with ESC’s Aquilion ONE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coronary arteries imaged in 0.35 second</td>
<td></td>
</tr>
<tr>
<td>Able to scan patients with cardiac arrhythmia</td>
<td></td>
</tr>
<tr>
<td>Whole heart perfusion</td>
<td></td>
</tr>
<tr>
<td>Whole brain perfusion</td>
<td></td>
</tr>
<tr>
<td>Whole organ perfusion</td>
<td></td>
</tr>
<tr>
<td>Dynamic orthopaedic studies</td>
<td></td>
</tr>
<tr>
<td>Separate arterial and venous maps</td>
<td></td>
</tr>
<tr>
<td>No patient movement for most studies</td>
<td></td>
</tr>
</tbody>
</table>
ESC on BBC One Panorama

Our multi award winning community cardiology scheme in partnership with Bexley Care Trust featured in a special edition of BBC One’s Panorama in September.

Presented by businessman and corporate trouble shooter Sir Gerry Robinson and appropriately titled ‘Gerry and the GPs’, the show explored differing opinions on the proposed NHS reforms, which will see GP-led commissioning groups taking control of budgets.

Our innovative project offers CT coronary angiograms to patients referred by Bexley GPs to a consultant-led community based rapid access chest pain clinic. It is regarded as one of the best examples of GP commissioning in practice in the country and proves just how well commissioning can work.

Gerry met with Bexley GP commissioner Dr Kosta Manis and Dr David Brennand-Roper, the consultant cardiologist who refers the patients to us for scanning. He travelled with the patients on the mini bus from Bexley to us and watched them undergoing CT coronary angiograms on our Aquilion ONE 640 slice CT scanner. The scanner provides the most accurate coronary angiogram, needing only one heartbeat to deliver a complete 3D image of a patient’s heart with the highest degree of accuracy currently available anywhere in the world.

An independent audit has shown this non-invasive investigation costs less than half of that for the usual battery of tests cardiac patients undergo, is safer and takes a fraction of the time. Patients not only benefit from a far shorter waiting time, but their diagnosis is swift and more accurate than ever before meaning that their treatment can start weeks earlier than they can expect under the ‘normal’ pathway.

Gerry, who was extremely impressed with our service and advanced technology, and recognised how our project represents a change for the better for all concerned parties, including the NHS, said:

“I was very impressed with the advanced technology and service received by the Bexley patients at the European Scanning Centre. The incredibly detailed 3D images produced are captured within a single heart beat and at one fifth of the radiation dose of traditional invasive angiograms. The ESC and Bexley Care Trust partnership is a truly wonderful innovation and a win-win model for all, as the scans are better for both patients and NHS finances.”

ESC achieves highest CQC registration

Quality is the cornerstone of everything we do at the ESC and we are proud to confirm that we have been successful in achieving full registration with the Care Quality Commission, the foremost body in the UK with responsibility for monitoring the performance of healthcare providers.

Although not obliged to obtain CQC registration we have sought and succeeded in achieving registration to the standard of an acute hospital care provider which is the most stringent available.

The standards cover every aspect of the services we provide including quality of care, governance, compliance with all required legislation and staff training and development.

This is not just a paper exercise as the new standards, which came into force last October, focus on outcomes and how we use and react to the information and data we collect as part of our everyday activities. A good example of this is how we learn from and utilise the feedback we receive from patients and our referring doctors (see the feature on Patient Satisfaction). In this way we can ensure that we are able to keep our service to patients and referring doctors under constant review and make improvements accordingly.

CQC is a notable achievement and is a serious undertaking for an organisation such as ourselves. It provides an external assessment of the standards to which we perform and underlines the importance we place on delivering the best quality of care and service.

Patricia passes NVQ Level 2 Health and Social Care

We are very proud to announce that our healthcare assistant Patricia Rocha has passed her NVQ Level 2 in Health and Social Care. This course has strengthened Patricia’s existing skills in optimising patient comfort, assisting with scan preparation, recognising patients’ individuality, privacy and dignity, and maintaining a safe care environment. Patricia adds “The course has really helped me understand the policies and procedures that underpin my daily work and how to ensure a safe, healthy environment for patients”. Patricia is looking forward to continuing her studies starting with a nursing course in a few months time.
ESC appoints Commercial Director

We are delighted to welcome Tim Walker to the European Scanning Centre who has been appointed as Commercial Director.

Tim has extensive experience of the independent healthcare sector having been CEO of a number of private hospitals. He has also developed and managed a group of nursing homes for a corporate provider and been responsible for several start up healthcare operations. He began his career in the NHS including 5 years at Great Ormond Street.

Tim’s main focus at ESC is to look after the commercial side of the business and as he says “be ESC’s ‘hospital director’.

Importance of bowel cancer screening

According to recent figures released by Cancer Research UK, the chances of getting colorectal cancer (CRC) in Great Britain has doubled for men and risen by more than a quarter for women.

Lifetime risk has increased from around one in 29 to around one in 15 for men and from one in 26 to one in 19 for women. Men also appear to be at higher risk of developing the disease with 18.5% of men in their early 50’s, compared with 10.7% of women having potentially malignant polyps. In all, more than 16,000 people die from CRC each year. Early screening, particularly for men is key to fighting this disease. CT virtual colonography is a relatively new non-invasive screening modality, approved by the National Institute for Health and Clinical Excellence (NICE). The American Cancer Association recommends it as a 5 yearly alternative to fibre-optic colonoscopy.

A CT virtual colonoscopy (VC) scan at the European Scanning Centre (ESC) is an excellent screening test to check for potentially pre-malignant polyps and early CRC. CT offers many advantages over the traditional fibre optic colonoscopy in that it has been proven to be just as sensitive in significant polyp detection but is far less invasive, much faster and safer without the associated risk of sedation or bowel perforation. What’s more, our 640 slice

Insurance company relations are a key priority as well as identifying and developing new business opportunities.

Tim is greatly enjoying working in Harley Street and is getting used to the daily commute from his home in West Sussex.

Outside work Tim has spent the past 10 years coaching and occasionally refereeing at his local rugby club.

High patient satisfaction at the ESC

We are proud of our patient care and work hard to ensure each patient’s time with us is as pleasant as possible. Our patient satisfaction survey is an important indicator of how well we achieve this and we monitor the results very closely.

The chart shows the percentage of patients responding to the ‘overall rating of service’ question with a rating of either poor, below average, average, good or excellent. This quarter 97.4% of respondents rated our service as either ‘Good’ or ‘Excellent’. The proportion recording a ’Poor’ or ‘Below Average’ experience was zero while ‘Average’ was just 2.6%.

ESC’s research news

In a recent collaboration between the European Scanning Centre (ESC) and Professor Michael Henein of Umea University and Heart Centre in Sweden, we are now participating in a multicentre international research programme in the field of coronary arteries and heart valve calcification.

Overall levels of service have remained at a similar high standard over the past year, indicating a consistent high level of patient satisfaction with our service.

Q2 2011 - overall rating of service

<table>
<thead>
<tr>
<th>Rating</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td>65.1%</td>
</tr>
<tr>
<td>Good</td>
<td>32.3%</td>
</tr>
<tr>
<td>Average</td>
<td>2.6%</td>
</tr>
<tr>
<td>Poor/Below</td>
<td>0.0%</td>
</tr>
</tbody>
</table>

In conjunction with Rachel Nicoll, a PhD candidate at Umea University, ESC is also participating in detailed biochemical investigations in angina patients with extensive arterial calcification, particularly in those with insignificant coronary stenosis. These patients are often the most difficult to manage because they generally do not respond to conventional anti-angina therapy and interventional procedures are limited. The objective of the biochemical studies is to identify the exact pathophysiology and metabolic disturbance which contribute to the development of extensive calcification. This may help in devising an evidence-based appropriate treatment programme and preventive measures for these patients.
Trial halted early as results show CT screening reduces lung cancer deaths

The National Lung Screening Trial (NLST) was set up to determine whether screening with low-dose CT could reduce mortality from lung cancer by detecting more cancers at early, curable stages.

In order to answer this question, The US National Cancer Institute ran the trial from August 2002 through to February 2004. They enrolled 53,000 former smokers between 55 and 74 years of age into the study and subjected them randomly to either a CT scan or x-ray to check for lung cancer.

The results published in August of this year in the New England Journal of Medicine show that screening with low dose CT reduced mortality from lung cancer by 20%. The trial was stopped a year early because of the overwhelming evidence of the results.

Currently, lung cancer is responsible for more deaths than any other type of cancer, partially due to the rapid advancement of the disease once symptoms present. Due to this, much of the research associated with lung cancer has been focused on finding ways to detect the disease earlier in its progression.

The NLST is the first randomized trial to show a significant reduction in mortality by CT screening, but several others are ongoing. One of the largest is the Dutch–Belgian NELSON trial, expected to report final results in 2015. This has a slightly different design, in that it is comparing 1 CT scan with usual care i.e. no screening, whereas the NLST compared 3 years of annual CT scans with annual chest x-rays.

Our Aquilion ONE scanner is the most advanced CT scanner worldwide and with its very high spatial resolution of just 0.3mm means we are able to visualise the chest in great detail while exposing patients to a very low radiation dose.

This study adds significant support to the suggestion that there is a real role for CT screening of individuals at high risk of developing lung cancer.

Bexley project praised by PM in his ‘can-do Britain’ speech

In his closing speech to the Conservative Party conference, the Prime Minister praised our award winning partnership with Bexley Care Trust for using NHS money ‘to cut waiting times, cut costs and improve care’.

In our innovative cardiology model, previously praised by health secretary Andrew Lansley, patients suspected of suffering from heart disease are seen in Bexley by a consultant cardiologist, rather than being automatically sent to a local hospital for tests. If necessary they are then referred to our clinic on Harley Street for CT coronary angiograms, paid for by Bexley but at significantly less overall cost than hospital tests. As well as being cheaper, the CT scans on our Aquilion ONE scanner are much safer than traditional invasive angiography and can also distinguish between soft and calcified coronary artery plaques. The former are those most likely to rupture and cause a heart attack.

In his speech, Mr Cameron said:

’Somewhere to succeed in this world, we need to become more like India, or China, or Brazil. I say: we need to become more like us. The real us. Hard-working, pioneering, independent, creative, adaptable, optimistic, can-do. That’s the spirit that has made this United Kingdom what it is: a small country that does great things; one of the most incredible success stories in the history of the world.’

‘And it’s a spirit that’s alive and well today…I see it in the group of GPs in Bexley who have taken more control of their budgets, and got their patients - some of the poorest in the country - free care on Harley Street. Their ambition? To cut waiting times, cut costs and improve care - all in one go. That’s leadership.’