CT Coronary Angiography Service Specification

from the British Society of Cardiovascular Imaging (BSCI)

Preamble

This document has been prepared in order to support those who commission cardiac imaging services, specifically CT coronary angiography (CTCA).

The key principle that should override all other considerations is that a cardiac CT service should be of demonstrably high quality irrespective of where or by whom it is delivered. A poorly performed or reported cardiac CT scan may lead to harm just as readily, if less directly, than a poorly performed invasive examination.

In consideration of the 'appropriateness' of CTCA as an investigation the key three questions to answer are –

- Is CTCA likely to provide an accurate diagnosis?
- Is CTCA likely to accurately identify patients who may benefit from specific therapies (such as revascularisation)?
- Will incrementally beneficial information regarding the patient's prognosis result from the CTCA?

At the current time standards for accrediting individuals to perform CTCA exist (through the British Society of Cardiovascular Imaging or BSCI) but not departments. This is likely to change over the next few years in line with other national cardiac imaging societies (such as the British Society of Echocardiography or BSE). One of the key points from the 2010 Cardiac Imaging Report from the National Imaging Board was that where such accreditation standards existed that these should be used as a basis for commissioning services.

The Technology and Equipment

There should be a robust well documented programme for equipment quality assurance, timely equipment replacement, appropriate IT systems and image archiving facilities. Within the near future the ability to utilise workstation functionality from a distant PC will enhance workflow and is likely to become commonplace. In general terms modern equipment provides more efficient and rapid image acquisition, workflow, analysis and reporting. It also improves availability of reports in an understandable format to clinicians.

For service planning purposes a reasonable replacement age for computed tomography (CT) equipment, with cardiac capabilities, is seven years.

Maintenance and quality assurance protocols for cardiac CT scanners, including calibration of equipment by appropriate personnel should be in place. This frequently involves liaison between different members of the workforce but is heavily dependent on medical physics experts who are also responsible for quality control and safety. The local medical physics department should be capable and responsible for checking and validating in house estimates of radiation dose specific to the cardiac CT scanner and protocols used locally (see below). A strong relationship with the local medical physics department is therefore crucial.

Equipment specifications

Apart from at specialist cardiac centres, a CT scanner will be used for a full range of examinations of the body. The following specification is for the cardiac element only. Technology in this area is changing rapidly and many new features are proving valuable in producing reliable high quality images at reduced doses. This specification should therefore be regarded as the minimum standard for new CT scanners at the current time.

The minimum requirement for CTCA is a 64 detector scanner with the associated cardiac hardware and software. The non- diagnostic rate of scanners with fewer detectors is 10% greater than those with 64 detectors, which is unacceptable. There are higher specification cardiac scanners with either higher

temporal or spatial resolution or coverage that provide incremental benefit at additional cost. The additional costs of such technology are currently at the discretion of the purchasers (see below).

The provision of prospective gating is, however, mandatory, as this has been shown to reduce the radiation dose in selected patients by up to 75%.

The position of the CT scanner within the hospital will be dictated by local circumstance ideally access from the trauma department and the coronary care and cardiac intensive care units should be considered because of CTCA's emerging role in acute cardiac conditions.

Contrast injectors used for CTCA should be able to deliver up to 7.5 ml/sec and be dual headed as the use of a saline "chaser" reduces contrast requirements and facilitates the detection of intra & extra cardiac shunts.

As the supervising consultant will need to review the case for technical success there is a requirement for an appropriate workstation (with cardiac software) within the control room of the scanner. The need for further workstations will be decided by local working practices, but generally at least one other is required because of the need for case review with clinicians.

Minimum equipment specification:

- 64 simultaneous slices per rotation
- 32mm Z-axis coverage or greater per rotation at the isocentre
- Prospective ECG gating and prospectively ECG triggered scan (axial scan)
- Retrospective ECG gating
- ECG controlled current modulation (helical mode)
- Minimum pitch of 0.2 for cardiac scanning
- Temporal resolution of at least 175mS for a single sector
- Scan plane resolution of at least 12.5lp/cm @10% MTF resolution
- Z-axis resolution of at least 8lp/cm@10%MTF
- ECG editing

- Contrast media bolus tracking
- Dual headed contrast media injector (may be supplied separately)
- ECG monitor
- Software packages to include:
    - CT Angiography
    - Coronary Vessel Analysis
    - Cardiac function & analysis
    - Cardiac calcium scoring

New generation cardiac CT scanners

CTCA is primarily performed to evaluate the coronary arteries. However in some patients imaging the coronary arteries (and surrounding anatomy) is difficult with type of CT scanners already described. Conditions that make CTCA difficult are:

- Obesity
- High levels of coronary artery calcification
- Arrhythmias
- High heart rates that cannot be lowered pharmacologically (over 65 beats per minute)
- Stents
- Previous bypass grafts

The so called new generation cardiac CT scanners have advantages over older types of CT scanners for these patients because of higher temporal and spatial resolution or greater coverage. In general terms the new generation cardiac CT scanners also have better contrast detection and provide lower radiation levels.

Details of the new generation cardiac CT scanners that have recently been the subject of a NICE diagnostic guideline (2012) are provided in the appendix below.

NICE recommends the new generation CT scanners as options for first-line imaging of the coronary arteries:

- In people with suspected stable CAD (with an estimated likelihood of coronary artery disease of 10-29%) in whom imaging with earlier generation CT scanners is difficult

- For first-line evaluation of disease progression, to establish the need for revascularisation, in people with known CAD in whom imaging with earlier generation CT scanners is difficult

Indications for CTCA are discussed below and were the subject of the NICE chest pain guideline in 2010. The recommendation to scan for disease progression in the 2012 diagnostic guidance represents an extension of the indications suggested in the 2010 clinical guideline.

The 2012 NICE diagnostic guideline was accompanied by comments from NICE including this statement from Professor Carole Longson, NICE Health Technology Evaluation Centre Director:

"*From a patient perspective, a non-invasive cardiac diagnostic test is more appealing than the current alternative for people in whom imaging is difficult - invasive coronary angiography - because of the greater morbidity and mortality risks associated with angiography. New generation cardiac CT was found to be more cost effective than angiography because of its lower imaging costs and the lower risk of adverse outcomes and associated reduced downstream healthcare costs from dealing with complications. The independent Diagnostics Advisory Committee concluded that the evidence presented indicated that new generation cardiac CT was more cost effective for people in whom imaging is difficult than proceeding directly to invasive angiography. Service providers in England, working with commissioners and cardiac networks, should take into account the benefits of new generation cardiac CT scanners for use in the circumstances described in this guidance when selecting CT scanners as part of medium term asset planning*."

There is no doubt that the new generation CT scanners provide improved diagnostic capability allowing expanded indications for testing, at a cost saving in terms of radiation dose to the patient. However this does not mean that the majority of CTCA cannot still be performed in a satisfactory way by existing services fulfilling the equipment specifications above. Indeed currently traditional 64 detector scanners provide the majority of such services across the United Kingdom. Perhaps the key take home message is that there may be good clinical governance and economic arguments in favour of upgrading to a new generation scanner when replacing existing CT systems if they are being used for CTCA.

There is one final important piece of equipment that needs to be of appropriate quality. A fully functioning, well stocked and maintained cardiac arrest trolley complete with a defibrillator capable of external pacing should be immediately available.

The Workforce

There is no doubt that a functional modern CTCA services requires collaboration between four groups of staff, namely radiographers, radiologists, cardiologists and physicists.

Radiographers

The major elements of a CTCA are acquired by CT radiographers and it is important that appropriate training and education has been given by senior colleagues, radiologists / cardiologists and application specialists. It is recommended that all CT radiographers in an institution rotate through cardiac CT in order that all are capable and confident to acquire a CTCA. It is recognised that many elements of the acquisition require judgement and clinical input:

- Scan type (contrast or not)?
- Administration of heart rate slowing drugs?
- Tube current and kV?
- Gating mode?
- Quantity and rate of contrast administration?
- Repeat scan needed?

These decisions dictate that, for the majority if not all cardiac CT acquisitions (and certainly all CTCA), the supervising cardiologist or radiologist should be present in the control room for the acquisition. This needs to be factored into the time allocated to consultants undertaking CTCA (see below).

Medical physics

There is a statutory requirement to consult a Radiation Protection Advisor (RPA) with regard to the planned introduction of a new CT scanner. This enables the selection, design and installation of the scanner to be considered with due respect to the Ionising Radiation Regulations act of 1999 (IRR99). This should happen before the equipment is purchased.

The details of the role that a medical physics expert (there is competence certification) plays in the delivery of a CT service is defined in the Ionising Radiation (Medical Exposure) Regulations of 2000, known as IRMER. A cardiac CT service is the most technically demanding of all CT services in this regard. Examples of this role include training, quality assurance, radiation protection, reporting of incidents, audit and indeed research. The only way to deliver an appropriately safe cardiac CT service is by collaborating with the local medical physics experts.

Radiologists and Cardiologists

Cardiac CT, and CTCA in particular, is technically demanding. To provide an effective service there should be a minimum of two trained clinicians, preferably one radiologist and one cardiologist, in any one institution. A cardiologist cannot provide this service in isolation – a radiologist needs to review the non-cardiac volume to look for important incidental findings in, for example, the lungs. Similarly only a handful of dedicated cardiac radiologists in the UK have sufficient knowledge of cardiology to provide this service without input from a cardiologist. The relationship between the two groups of clinicians here is in fact synergistic and a combined service is the firm recommendation.

In 2011 a National Tariff for cardiac CT was developed by the BSCI and this has been accepted for use in local negotiations (available at www.bsci.org.uk/ct-cmr-tariffs). The modelling for this tariff suggested that during 2.5 sessions of direct clinic care a consultant would oversee the acquisition of and report on 2 sessions of cardiac CT. The number of patients scanned during a session would total 8 (16 for 2 sessions), commonly a mixture of cardiac CT and CTCA.

In 2009 the BSCI developed individual accreditation processes for those training in cardiac CT. This accreditation process is now well established. A clinical cardiac CT service should be provided by clinicians certified at a minimum of Level 2 with the BSCI although it should be noted that the BSCI process merely accredits and does not check competence. It remains the responsibility of individual clinicians to ensure that they are suitably trained and competent to provide the service that is offered. Whilst networking between hospitals with remote reporting can provide a reporting service there is a current need for direct supervision (see above) at the time of image acquisition for CTCA. As of 2012 the

BSCI have also developed and published some guidance with regards to revalidation in cardiovascular CT. The Society aspires to the development of departmental accreditation, much like BSE provide.

The final aspect of care that the whole workforce should be able to demonstrate competence in is the management of adverse reactions and resuscitation. Up to date training in resuscitation should be maintained. Furthermore given the nature of the patients under investigation and the administration of heart rate slowing drugs at least one member of the workforce (for any given session) should be trained and certified in advanced life support.

CTCA / cardiac CT

Cardiac CT is an excellent trouble-shooting diagnostic tool which can be used to assess congenital heart disease, cardiac tumours, pericardial disease, great vessel pathology and valvular heart disease. Along with the CTCA service provided it should be expected that a certain amount of this type of work (which will vary according to the population served and particularly the presence or absence of cardiac surgical services) will be required. The vast majority of the service will be geared to CTCA however.

Current CTCA applications

As outlined in the 2010 NICE guideline for assessment of recent onset chest, with a pre-test likelihood of IHD of 10-29%, CT scanning is the modality of choice. This NICE guideline recommends an initial unenhanced scan only proceeding to CTCA if there is evidence of a non-severe amount of coronary artery calcification. However the consensus opinion from the BSCI is that this approach is over cautious now that radiation doses have fallen dramatically. This initial intention should therefore be to investigate this patient group with a CTCA, falling back on the unenhanced scan only if the patient is unsuitable for full investigation.

There is no reason why this service cannot be provided directly to referring General Practitioners with cardiology (including ECG) assessment taking place on the CT table as the patient is prepared for the CTCA.

The decision whether to provide CTCA (and graft angiography) for patients with established IHD, or a higher likelihood of such, depends entirely on the facilities available and local expertise. An objective reflection of the local expertise required to undertake this form of imaging would be the attainment of BSCI Level 3 accreditation or equivalent. The NICE diagnostics guidance regarding the new generation cardiac CT scanners opens this door for service providers. Therefore it is expected that highly experienced practitioners armed with a new generation cardiac CT scanner will offer CTCA for these patients to assess the need for revascularisation, whereas those without this facility will not. Similarly it is only centres that have a new generation scanner which are going to provide CTCA services for those patients who are 'difficult' to scan with the more basic CT scanners.

Emerging applications include

- Acute chest pain with negative or borderline biochemical markers for myocardial infarction and a non-acute ECG
- Pre-operative assessment
- Screening those with a family history of premature IHD not taking statin therapy.

Radiation

This is a key issue for service providers. There is no doubt that the new generation cardiac CT scanners provide radiation dose saving advantages. There are however a number of radiation dose saving strategies that should be employed regardless of the level of technology used (prospective gating and 100 kV scanning for example). Service providers should hold a database of patients evaluated including the Dose Length Product, stored appropriately in collaboration with local IT services. Regular dose audit in comparison to national standard should be undertaken. Once national processes are in place cardiac CT doses will need to be submitted centrally. The principles in IRMER should be understood and adhered to.

Reporting and data storage

Cardiac CT data needs to be stored fully and appropriately to PACS along with the report. The minimum content for a report is:

- Patient details and demographics
- Indication for scan
- Scan undertaken
- Patient's heart rate, rhythm and BMI
- Contrast and heart rate slowing drugs administered
- Scan parameters
- Details of calcium score
- Comment on CTCA image quality, and reason if sub-optimal
- Full coronary angiography report
- Additional abnormal cardiac findings
- Additional abnormal non-cardiac findings
- Summary
- A clinical comment / onward recommendation is also often helpful

The cardiologist / radiologist reporting needs therefore to be supported by appropriate clerical staff, who may be required to type the report, transfer any urgent findings, book onward investigations and facilitate data storage.

Conclusions

CTCA and CTCA services are developing rapidly and any service specification will require regular up-dating.

To offer a CTCA service for low-intermediate likelihood of IHD chest pain patients the minimum requirements are:

- 2 BSCI Level 2 trained clinicians preferably a cardiologist and a radiologist
- A 64 detector, cardiac enabled, CT scanner with prospective gating
- A trained workforce including medical physics experts
- Appropriate infrastructure, support staff, IT, and clinical governance processes including regular audit of radiation doses

To offer an extended CTCA / cardiac CT service to include patients with established / high likelihood of IHD and 'difficult' to scan patients there are further requirements, which include:

- A new generation cardiac CT scanner
- Demonstrable expertise in cardiac CT above and beyond that required for BSCI Level 2 accreditation (for example BSCI Level 3 accreditation)

Service providers, working with commissioners and cardiac networks, should take into account the benefits of access to new generation cardiac CT scanners when selecting CT scanners as part of medium term asset planning.

References (web references correct as of 18/03/12)

- ACCF/ACR/AHA/NASCI/SAIP/SCAI/SCCT 2010 Expert consensus document on coronary CT angiography, JACC, 55, No 23, 2010

- NICE chest pain guideline, 2010 (http://publications.nice.org.uk/chest-pain-of-recent-onset-cg95)

- NICE diagnostics guidance on new generation cardiac CT scanners, 2012 (http://publications.nice.org.uk/new-generation-cardiac-ct-scanners-aquilion-one-brilliance-ict-discovery-ct750-hd-and-somatom-dg3)

- Cardiac imaging – A report from the national imaging board, 2010 (http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_114380)

Appendix

Details of the new generation cardiac CT scanners that have recently been the subject of a NICE diagnostic guideline (2012) are the Somatom Definition Flash CT scanner (Siemens AG Healthcare), Aquilion ONE (Toshiba Medical Systems), Brilliance iCT (Philips Healthcare) and the Discovery CT750 (GE Healthcare):

Aquilion ONE

The Aquillion ONE is a CT scanner with 320 x 0.5 mm detector rows giving z-axis coverage of 160 mm. This specification allows the imaging of the whole heart in a single rotation of the gantry. The entire cardiac volume can be captured in a heartbeat therefore reducing the contrast, radiation dose and examination time.

Brilliance iCT

The Brilliance iCT is a CT scanner with 128 x 0.625 mm detector rows providing total z-axis coverage of 80 mm. Each detector row is doubled sampled to increase spatial resolution. The intention is to capture the image of the whole heart in two heart beats.

Discovery CT750 HD

The Discovery CT750 HD is a 64 x 0.625mm detector dual-energy CT scanner. It has a single X-ray source that switches between two energy levels, allowing two data sets – high energy and low energy –to be acquired simultaneously. It uses a Gemstone detector that contributes to high image quality (reduced spatial resolution or 'high definition' scanning), and a prospectively gated axial scanning technique, which allows the heart to be captured in three or four separate rotations.

Somatom Definition Flash

The Somatom Definition Flash is a second generation 128 x 0.6 mm detector dual source CT scanner that is designed to provide high resolution images with a fast scanning speed (maximal temporal resolution of 75ms) and low radiation doses. It has two x-ray tubes and two detectors mounted at 90 degrees to each other. The scanner uses a novel acquisition algorithm with a high scan speed of 458 mm/s.