BSCI/BSCCT Guidance for Cardiovascular CT training (Cardiology)

1. Core training

This document outlines the details of the BSCI recommendations for core training and should be read in conjunction with the 2010 cardiology curriculum as an adjunct to these documents. This document offers more detail on the recommended experience, knowledge and behaviours that will allow trainees to demonstrate acquisition of the required competencies. It is acknowledged that most hospitals performing cardiovascular CT in the UK only do one or two cardiac CT lists a week making a definitive time requirement to gain the experience below problematic, particularly in the short term. The BSCI provides a useful checklist for core training at **appendix 1.**

To gain core competence in cardiovascular CT it is likely that trainees will need the following knowledge and experience:

a) **Interpreting 50 Contrast CT coronary angiograms** (including both retrospectively and prospectively ECG gated).

The case mix should ideally include:

. i) Stent and graft cases

. ii) Calcified and non-calcified atheromatous disease

. ii) Coronary Calcium Scores (Non-contrast studies*)

. iii) Left ventricular function assessment (retrospectively gated studies)

. iv) Simple congenital heart disease

. v) Coronary artery anomalies

. vi) Valvular pathology

. vii) Aortic pathology including dilatation and coarctation

*may be part of CT coronary angiogram study

If possible, additionally experience of: Pericardial Disease, Pulmonary venous anatomy, Cardiac masses / tumours.

b) A basic understanding of:

. i) Cardiovascular CT capabilities (64 -320 detector technology, Dual Source, FLASH technology)

. ii) Cardiovascular CT indications and contraindications

. iii) Radiation safety (including IR(ME)R guidelines)

. iv) Cardiovascular CT procedure (acquisition parameters, prospective and retrospective ECG gated protocols)

. v) Cardiovascular CT imaging protocols

. vi) Cardiovascular CT post-processing

. vii) Cardiovascular CT interpretation in clinical context

. viii) Cardiovascular CT limitations

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Recommended learning methods include:

. a) Self directed learning - including dedicated computer programs with fifty cardiac CT cases fulfilling the above required numbers and case mix.

. b) Dedicated teaching (e.g. tuition by imaging cardiologists and radiologists)

. c) Hospital meetings (e.g. departmental teaching, journal review, grand round presentations, study days, conferences, cardiac radiology meetings)

. d) Local or national postgraduate education

. e) Apprenticeship learning

. f) In-house specialist teaching material.

1.1 Core training - additional Recommendations:

Although not mandatory, core trainees should consider attendance at one or more of the meetings outlined in Section 4.1, particularly for those considering undertaking advanced training. Additionally BSCI recommends certain courses, self directed learning resources, online reading and books (see Section 4).

2. Advanced training (to level 2)

UK advanced training in cardiovascular CT aims to give trainees competence to run a Cardiovascular CT programme. This is the equivalent of the internationally defined SCCT level 3 clinical competence as described in the ACC Cardiovascular CT training document (download here). To achieve this level of competence trainees need a much more detailed knowledge of the subject of cardiovascular CT and importantly other cardiovascular imaging modalities. This extends to both the role of Cardiovascular CT in the management of a wide range of heart disease but also the technical aspects of how to obtain high quality information for all the different indications and how to process and report the scans.

The advanced training requirements are outlined here and mirror those international guidelines for training in Cardiac CT available here.

To gain advanced competence in cardiovascular CT, trainees having completed core specialty training are likely to need 12 months training which could comprise:

a) **6 months experience devoted purely to cardiovascular CT training** (in a high volume cardiovascular centre).
b) 6 months additional experience concurrent with outher cardiovascular imaging training
c) Protocol involvement at the time of acquisition of **at least 100 studies**. **Supervised reporting of at least 300 studies**, of which, **primary reporting of at least 100 studies.**

The case mix should ideally include:

- coronary artery disease (CT coronary angiography with and without stents)
- coronary artery disease (Coronary Artery Bypass Grafts)
- coronary artery anomalies
- left ventricular function assessment (Global and regional function)
- aortic, mitral, tricuspid and pulmonary valve pathology
- aortic pathology including dilatation and coarctation
- simple and complex congenital heart disease
- pericardial abnormality
- cardiac mass/tumour
- angiography of major arteries including aorta, pulmonary, carotid and renal
- right ventricular function assessment
- pulmonary venous anatomy
- coronary sinus anatomy
- detection of myocardial infarction (first pass studies)
- myocardial perfusion (late pass studies)

d) A detailed understanding of the types of protocol available, the strengths and limitations of each and the parameters which must be optimised for each protocol, all allied with an understanding of the physics of Cardiovascular CT and

ionising radiation and how it impinges on the clinical process. This should include an understanding of:

- Indications and risk factors that might increase the likelihood of adverse reactions to contrast media

- Radiationexposurefactors - CTscancollimation(slicethickness)

- CT scan temporal resolution (scan time per slice)

- Table speed (pitch)

- Field of view

- Window and level view settings

- Algorithms used for reconstruction

- Contrast media

- Presence and cause of artifact

- Post-processing techniques and image manipulation on work stations

- Total radiation dose to the patient

e) Clinical role Advanced trainees need adequate exposure to all aspects of provision of a clinical Cardiovascular CT service. This would include:

- Vetting of referrals for appropriateness and consideration of ionising radiation safety.

- Organising Cardiovascular CT lists

- Liaising with other members of the radiology and cardiology teams.

- Oversee Cardiovascular CT lists

- Report on scans with supervision.

- Retain a close involvement with the clinical activities of the department, including audit and other quality assurance programmes. - Close involvement with combined cardiology/imaging meetings, presenting Cardiovascular CT cases.

- On-call commitment should be adequate to meet continuing training requirements.

f) Cardiac CT research presented at regional/national meetings or published in peer reviewed journals Additional desirable attributes include:

g) a higher degree involving Cardiovascular CT h) BSCI/SCCT Level 2/3 Accreditation

Recommended learning methods include:

. a) Self directed learning (e.g. textbooks, journals and internet sources)

. b) Dedicated teaching by consultant staff (e.g. period of tuition by cardiologist or radiologist)

. c) Hospital meetings (e.g. surgical conferences, cardiac radiology meetings)

. d) Local postgraduate education (e.g. departmental teaching, journal review, grand round presentations)

. e) Foundation courses and study days

. f) Attendance (or presentation of research) at regional, national and international conferences)

. g) Reflective commentary about anonymised patients in the portfolio of educational achievements

. h) Apprenticeship learning (experiential learning)

. i) Participation in research and audit supervised by consultant trainer

. j) Participation in teaching

. k) Participation in management

. l) Use of in-house specialist teaching material

3.1 Assessment Methods

JRCPTB training record or RCR training portfolio - This will document assessments carried out by training supervisors and include evaluation by the trainee's educational supervisor. These should be available for ARCP or equivalent as required. These assessments should consist of:

i) direct observation of the trainee by trainers
ii) feedback from other staff members
iii) feedback from patients and/or their carers/parents

In addition educational supervisors will:

a. Inspect the trainee's portfolio of educational achievements (which should present evidence of a trainee's progress in acquiring the necessary knowledge, generic and clinical skills, and experience)

b. Inspect the trainee's log book (which should record investigations or procedures performed by the trainee)

c. Evaluate the trainee's critical reflection on events in clinical practice (the assessor should examine the trainee's documentation of points learned from the care of individual patients).

New methods of assessment MSF, Mini-CEX, DOPs, CbD and PSS

New methods of training and assessment have been introduced to allow a more structured approach to assessing trainees' competency. Below are outlined

recommendations for the Cardiovascular CT component of advanced cardiac imaging training. The 3 components of the new methods of training that apply to both radiology and cardiology are DOPS (directly observed procedural skill), 360 degree assessment and Mini-CEX/IPX (clinical evaluation exercise/image interpretation exercise). 2 additional components that apply to cardiology are CbD (Case based Discussions) and PSS (patient satisfaction survey).

These should be used in conjunction with traditional methods, such as maintenance of a logbook as outlined in the current guidelines, and be part of the regular supervisor appraisal processes that contributes to the educational supervisor's assessment and report. A 360 degree Multi-source feedback should be performed as per JRCPTB/RCR guidelines. A PS should also be performed as per current JRCPTB guidelines.

The following are recommended:

Assessors: Consultants running a Cardiovascular CT service (Ideally Level 3 SCCT/BSCI).

Number of assessments: 6-8 per year

Estimated time required:

DOPS: the length of a scan plus 10 minutes

Mini-CEX/IPX: 20 minutes (15 min assessment, 5 min feedback)

CbD: 20 minutes (15 min assessment, 5 min feedback)

MSF (360): one very two years (20 respondents, 30 min feedback)

PS: one every two years

3.1.1 DOPS

These assess the ability to correctly perform a technical procedure. Reference is made to the SCCT guidelines for performance of coronary computed tomographic angiography. It is important that trainees develop a portfolio of DOPS to demonstrate their competence. Whilst in some cases this may be limited by local practice, trainees should consider training opportunities in other CT centres to maximise their exposure to a broad range of clinical scenarios. The DOPS can be documented in the standard format on the trainee's e-portfolio, but the components of each may additionally be scored from 1 to 9 as follows:

A score of 1-3 is considered unsatisfactory, 4-6 satisfactory and 7-9 is considered above that expected for a trainee at the same stage of training and level of experience. A score of 1-3 should be justified with at least one explanation/example in the comments box; failure to do so will invalidate the assessment. Anchor statements will indicate the degree of independence that the trainee has demonstrated i.e. grade 1 – able to perform the procedure under direct supervision/assistance, grade 2 – able to perform the procedure with limited supervision/assistance grade 3 – competent to perform the procedure unsupervised and deal with complications. Additional comments and other relevant opinions about this doctor's strengths and weaknesses are welcome. Further guidance for DOPs can be found on the JRCPTB website here and the RCR website here.

BSCI recommended DOPS:

. 1) CT Coronary Angiography

. 2) CT Calcium score

. 3) Coronary Artery Bypass Graft Assessment

. 4) Global and Regional LV Function

. 5) Basic Congenital Heart Disease

The generic DOP's form should be used in each case. This is either available online via http://www.jrcptb.org.ukor can be accessed directly via a trainees e-Portfolio.

In more detail, DOPS should cover the following areas:

1) DOPS: CT coronary angiography

. a) Interacts appropriately with patient

. b) Able to position patient within CT scanner with due regard to safety and comfort

. c) Appropriate use of pharmacological agents to achieve appropriate heart rate (Aware of alternatives and contraindications to pharmacological agents)

. d) Appropriate use of prospective or retrospective protocol (age, rhythm dependent)

. e) Correctly times contrast bolus

. f) Able to post process and interpret images (Axial, VR, MIPS, MPR)

. g) Able to interpret and report images appropriate to the clinical context

2) DOPS: CT Calcium score

. a) Interacts appropriately with patient

. b) Able to position patient within CT scanner with due regard to safety and comfort

. c) Appropriate acquisition plane

. d) Appropriate use of correct protocol

. e) Able to post-process and interpret images

. f) Understands clinical implications of result

3) DOPS: Coronary Artery Bypass Graft Assessment

. a) Interacts appropriately with patient

. b) Able to position patient within CT scanner with due regard to safety and comfort

. c) Appropriate adjustment to acquisition plane (extended coverage)

. d) Appropriate use of pharmacological agents to achieve appropriate heart rate (aware of alternatives and contraindications to pharmacological agents)

. e) Appropriate use of prospective or retrospective protocol (age, rhythm dependent)

. f) Correctly times contrast bolus

. g) Able to post process and interpret images (Axial, VR, MIPS, MPR)

. h) Able to interpret and report images appropriate to the clinical context

4) DOPS: Global and regional LV function

. a) Interacts appropriately with patient

. b) Able to position patient within CT scanner with due regard to safety and comfort

. c) Knowledge of the requirements for LV analysis (i.e. retrospectively gated or broad prospective gating including end systole and diastole)

. d) Appropriate use of pharmacological agents to achieve appropriate heart rate and understanding of potential effect on global LV function.

. e) Aware of alternatives and contraindications to pharmacological agents

. f) Correctly times contrast bolus

. g) Able to post process and interpret images (Axial, VR, MIPS, MPR, calculation of chamber volumes and ejection fraction)

. h) Able to interpret and report images appropriate to the clinical context

5) DOPS: Basic Congenital Heart Disease

. a) Interacts appropriately with patient (especially if learning disabilities or paediatric)

. b) Able to position patient within CT scanner with due regard to safety and comfort

. c) Knowledge of the requirements for ACHD analysis (i.e. retrospectively gated or broad prospective gating including end systole and diastole)

. d) Appropriate use of pharmacological agents to achieve appropriate heart rate (Awareness of risks and limitations of pharmacological agents in congenital heart disease)

. e) Appropriate use of additional or extended protocols to answer clinical question

. f) Knowledge of correctly times contrast bolus particularly in patients with Fontan type circulation and awareness of issues in patients with right to left shunts.

. g) Able to post process images (Axial, VR, MIPS, MPR)

. h) Able to interpret and report images appropriate to the clinical context

3.1.2 Mini-CEX and Case Based Discussions (CBD):

These test the ability to interpret the images and then to relate these findings to the appropriate clinical context. CbD is designed to assess clinical decision-making and the application or use of medical knowledge in the interpretation of Cardiovascular CT studies, and, to a lesser extent, report writing. As with DOPS, it is important that trainees develop a portfolio of Mini-CEXs and CbDs to demonstrate their breadth of understanding. Further guidance for CbD's can be

found on the JRCPTB website here. Whilst in some cases this may be limited by local practice, trainees should consider training opportunities in other CT centres to maximise their exposure to a broad range of clinical scenarios.

. 1) Coronary Calcium Scoring

. 2) CT Coronary Angiography – prospective vs. retrospective protocols

. 3) CT Coronary Angiography – vs. invasive angiography

. 4) CT Coronary angiography – vs. functional cardiovascular imaging (i.e. MPS/DSE/Perfusion CMR)

. 5) Resting Ventricular Function (Global and Regional)

. 6) Aortic disease

. 7) Pulmonary arterial disease and RV function

. 8) Ischaemic heart disease (Infarction)

. 9) Pericardial disease/cardiac masses

. 10) Non –Ischaemic Cardiomyopathy (including HCM and myocarditis)

. 11) Congenital Heart Disease

. 12) Use of cardiac CT in assisting electrophysiology procedures

. 13) Radiation dose in Cardiac CT and mechanisms to reduce exposure

. 14) Knowledge of extra-cardiac findings

The generic Mini-IPX or CbD form should be used in each case. This is either available online via http://www.jrcptb.org.ukor can be accessed directly via ePortfolio. In detail, the types of area to be assessed with CBD are described below.

. **1) CBD: Coronary Calcium Scoring**

. a) Understands role for coronary calcium scoring as a screening tool

. b) Understand strengths and limitations of coronary calcium scoring in asymptomatic patients and as part of a CT coronary angiography protocol for chest pain assessment with particular emphasis on national guidelines (e.g. NICE)

. c) Understand effect of coronary calcium on luminal assessment in CT coronary angiography

. **2) CBD: CT Coronary Angiography – prospective vs. retrospective protocols**

. a) Understands the principles of prospective and retrospective gated Cardiovascular CT studies

. b) Understands strengths and limitations of each approach e.g. Radiation dose reduction, loss of functional information, artefact analysis etc.

. c) Awareness of vendor specific approached to prospective and retrospective data acquisition

3) CBD: CT Coronary Angiography –vs. invasive angiography

. a) Understands the strengths and limitations of CT Coronary angiography vs. invasive angiography

. b) Able to assess overall patient risk of each technique

. c) Understand differences in spatial and temporal resolution between CT Coronary Angiography and invasive coronary angiography

. d) Understand basic invasive coronary angiography planes and the potential limitations of comparing both techniques

- e) Understands role of plaque assessment for both techniques and standard tools for quantification of stenoses (i.e. QCA) and the limitations in comparing techniques

4) CBD: CT Coronary Angiography –vs. functional cardiovascular imaging

. a) Understands the strengths and limitations of CT Coronary angiography vs. alternative non- invasive functional tests e.g., MPS, DSE and Stress CMR

. b) Knowledge of the strengths and weakness of each test in assessing ischaemic heart disease.

. c) Understanding of arguments between anatomical and functional imaging for ischaemic heart disease, including plaque vulnerability

. d) Able to correctly interpret resting LV function data in conjunction with CT coronary angiography

. e) Able to correctly interpret Early/Late Pass enhancement data

. f) Able to write an appropriate, cogent report that is relevant to the clinical problem

5) CBD: Resting Ventricular Function (Global and Regional):

. a) Able to correctly assess global LV function

. b) Able to correctly describe regional wall motion using standard terminology i.e. hypokinesis, akinesis, dyskinesis.

. c) Constructs report using the AHA 17 segment model

. d) Able to correctly calculate LV volumes

. e) Ability to use at least one analysis package, and awareness of problem areas (eg apical slices, basal slice and mitral valve in-plane motion)

. f) Able to correctly interpret volumetric data

. g) Uses appropriate reference ranges (for imaging and analysis used)

. h) Able to write an appropriate and cogent report that is relevant to the clinical problem

6) CBD: Aortic disease

. a) Understands the role of cardiac CT in the diagnosis and follow-up of aortic disease

. b) Able to appropriately assess aortic size

. c) Aware of other imaging modalities used in the assessment of aortic disease (MRI / invasive angiography) and their relative strengths and weaknesses

. d) Knowledge of the role of cardiac CT in the assessment of patients undergoing aortic interventions (TAVI, aortic stents)

. e) Able to write an appropriate and cogent report that is relevant to the clinical problem

7) CBD: Pulmonart arterial disease and RV function

. a) Understands the role of cardiac CT in assessment of pulmonary disease

. b) Awareness of other imaging modalities used in the assessment of pulmonary vascular disease (MR and nuclear techniques) and their relative strengths and weaknesses

. c) Knowledge of pulmonary arterial and venous anatomy

. d) Able to calculate RV size and function

. e) Able to write an appropriate and cogent report that is relevant to the clinical problem

8) CBD: Ischaemic heart disease (Infarction)

. a) Knowledge of how myocardial infarction can be assessed by CT (e.g. wall motion abnormalities, wall thinning, “late enhancement”

. b) Understands importance of reporting cardiac wall abnormalities even on prospective scans with no functional information.

. c) Able to write an appropriate and cogent report that is relevant to the clinical problem

9) CBD: Pericardial disease/cardiac masses

. a) Able to determine an appropriate differential diagnosis based on the imaging

. b) Knowledge of pericardial anatomy

. c) Knowledge of masses found in the heart

. d) Able to write an appropriate and cogent report that is relevant to the clinical problem

10) CBD: Non –Ischaemic Cardiomyopathy (including HCM and myocarditis)

. a) Knowledge of how cardiomyopathy can be diagnosed by CT

. b) Knowledge of other complementary imaging techniques used to assess patients with cardiomyopathy (CMR, echo) and their relative strengths and weaknesses

. c) Able to write an appropriate and cogent report that is relevant to the clinical problem

11) CBD: Congenital Heart Disease

. a) Understanding and appropriate use of sequential analysis for congenital heart disease cases

. b) Appropriate calculation of LV and RV volumes (as appropriate)

. c) Appropriate awareness of surgical procedures and the assessment of post operative cases

. d) Able to write an appropriate and cogent report that is relevant to the clinical problem

12) CBD: Use of cardiac CT in assisting electrophysiology procedures

. a) Understanding of the role Cardiac CT has in assisting EP procedures

. b) Knowledge of pulmonary and cardiac venous anatomy

. c) Able to produce appropriate constructions of the area of interest

. d) Knowledge of CT image integration into EP labs

. e) Able to write an appropriate and cogent report that is relevant to the clinical problem

13) CBD: Radiation dose in Cardiac CT and mechanisms to reduce exposure

. a) Awareness of the importance of radiation safety and the risks involved in radiation exposure

. b) Awareness of vendor specific mechanisms to reduce radiation exposure

14) CBD: Knowledge of extra-cardiac findings

. a) Awareness of extra-cardiac structures scanned during cardiac CT

. b) Knowledge of important extra-cardiac abnormalities that require further action

. c) Understanding for the need for close radiological and Cardiological working

d) Able to write an appropriate and cogent report that is relevant to the clinical problem

4. BSCI Recommended Educational Resources

4.1 BSCI Recommended Meetings:

Although not mandatory, core trainees can consider attendance at one or more of the following, particularly if they are considering undertaking advanced

training: BSCI recommend that all cardiology trainees attend the cardiovascular CT sessions at BCS and radiology trainees attend the cardiovascular CT sessions at UKRC at least once in their training. Subspecialty trainees would be expected to attend regular meetings both to remain aware of current advances in cardiovascular CT and also ideally to present their own presentations/research.

The BSCI annual meetings (see here for information)
The BCS annual meeting cardiovascular CT sessions (see here for information).
The UKRC annual meeting cardiovascular CT sessions (see here for information)
The ICNC annual meeting cardiovascular CT sessions (see here for information)
The SCCT annual meeting (see here for information)
The RSNA annual Meeting cardiovascular CT sessions (see here for information)
ESC meeting (see here for information)
There are a number of regional meetings (e.g. SW Imaging Network (SWINE)) and local meetings. See www.bsci.org.uk for details.

4.2 BSCI Recommended Courses

Trainee attendance at formal Cardiovascular CT courses is not mandatory, but for those interested, current courses can be found at here and here. London Cardiology STC and the BSCI run an annual meeting on Cardiac CT in collaboration with the radiology and cardiology sections of the Royal Society of Medicine and details can be found here.

4.3 BSCI recommended Self-directed learning resources

Web resources include

BSCI recommended Self-directed learning resources

Web resources include

1. **BSCI** education material
2. **SCCT**: http://www.scct.org/
3. **ESC**: http://www.escardio.org
4. **ASNC**: http://www.asnc.org/

4.4 BSCI suggested introductory online reading

a) Assessment of coronary artery disease by cardiac computed tomography
b) SCCT guidelines for the interpretation and reporting of coronary computed tomographic angiography
c) ACCF/ACR/ SCCT/SCMR/ASNC/NASCI/SCAI/SIR 2006 Appropriateness Criteria for Cardiac Computed Tomography and Cardiac Magnetic Resonance Imaging
d) Consensus Update on the Appropriate Usage of Cardiac Computed Tomographic Angiography
e) Cardiac Drugs used in Cross-sectional Cardiac Imaging: what the Radiologist needs to know. Clin Radiol 2010;**65**: 677-684
f) Considerations When Starting A New Cardiac MDCT Service, Avoiding the Pitfalls. Clin Radiol 2008;**63**: 355-69

4.5 BSCI suggested introductory books

1. Cardiac CT Made Easy by Paul Schoenhagen, Arthur E. Stillman, and Richard D. White (Paperback - 8 Dec 2005)
2. Oxford Handbook of Cardiovascular CT (Paperback) by Ed Nicol, Jim Stirrup, Simon Padley and Andrew Kelion. (2011)

3. Multi-slice and Dual-source CT in Cardiac Imaging: Principles, Protocols, Indications, Outlook by Bernd M. Ohnesorge, Thomas G. Flohr, Christoph R. Becker, and Andreas Knez (Hardcover - 19 Oct 2006)

4. Cardiac CT Imaging by Matthew J. Budoff and Jerold S. Shinbane (Hardcover - 1 Jun 2010)

Appendix 1

Core training in cardiovascular CT (cardiology trainees) Checklist for requirements				
Requirements:	Completed?		Date?	
Observation of 50 cases				
Knowledge				
CARDIAC CT Knowledge checklist				
Capabilities				
Indications/contraindications				
Safety/Radiation Knowledge				
Procedure				
Imaging protocols				
Post-processing				
Interpretation in context				
Limitations				
Meeting Attendance (local, regional, national, international)				
Cases checklist				
	Observed	Assisted	Analysed	Co-reported
50 CT coronary angiograms (including 10 graft/stent cases)				
10 Coronary Calcium Scores*				
10 LV function assessment (retrospective dataset)				
simple congenital heart disease				
aortic pathology inc. dilatation and coarctation				
**Right ventricular function assessment				
**Valvular Pathology				
**CT Pulmonary Angiography				
**Pericardial Pathology				
**Angiography of major artery abnormality				

*may be part of CT coronary angiography protocol
**optional items desirable if the trainee is considering imaging as a subspecialty

Appendix 2

BSCI Guidance for Cardiovascular CT training Version 1.6, August 2010

The following contributed to the writing of this document:

Dr Ed Nicol (Cardiology Specialist Registrar, Royal Brompton Hospital, London, BSCI Trainee representative (Cardiology)) Dr Ceri Davies (Consultant Cardiologist, London Chest Hospital, London, BSCI Education Subcommittee)

Dr Stephen Harden (Consultant Cardiac Radiologist, Southampton General Hospital, Chairman BSCI Education Subcommittee) Dr Roger Bury (Consultant Radiologist, Royal Victoria Hospital, Blackpool, BSCI President

Professor Carl Roobottam (Consultant Radiologist, Derriford Hospital, Plymouth) Dr Paula McParland (Radiology Specialist Registrar, Southampton General Hospital, BSCI Trainee representative (Radiology))

The document was reviewed by the BSCI Executive Committee who are (June 2010):

Dr Roger Bury (Consultant Radiologist, Royal Victoria Hospital, Blackpool, BSCI President) Dr Charles Peebles (Consultant Cardiac Radiologist, Southampton General Hospital, Past President of the BSCI) Dr Mark Hamilton (Consultant Radiologist, Bristol Royal Infirmary, BSCI Secretary) Dr Giles Roditi (Consultant Radiologist, Glasgow Royal Infirmary, BSCI Treasurer) Dr Stephen Harden (Consultant Cardiac Radiologist, Southampton General Hospital, Chairman BSCI Education Subcommittee) Dr Ceri Davies (Consultant Cardiologist, London Chest Hospital, London, BSCI Education Subcommittee) Dr Tarun Mittal ((Consultant Radiologist, Harefield Hospital, Middlesex) Dr Gareth Morgan Hughes (Consultant Cardiologist, Derriford Hospital, Plymouth) Professor Carl Roobottam (Consultant Radiologist, Derriford Hospital, Plymouth) Professor Andrew Taylor (Consultant Radiologist, Great Ormond Street Hospital, London) Dr Ed Nicol (Cardiology Specialist Registrar, Royal Brompton Hospital, London, BSCI Trainee representative (Cardiology)) Dr Paula McParland (Radiology Specialist Registrar Southampton General Hospital, BSCI Trainee representative

(Radiology))

The writing committee would like to express their thanks and acknowledge the following individuals for their comments and help in the preparation of this document:

Dr Mark Westwood, Imaging Lead London Cardiology STC, consultant cardiologist, The London Chest Hospital, London

Professor Stefan Neubauer, President of the British Society of Cardiovascular Magnetic Resonance (BSCMR), Professor of Cardiovascular Medicine, Dept of Cardiovascular Medicine, John Radcliffe Hospital, Oxford

Dr James Moon, Education Lead, BSCMR, consultant cardiologist, The Heart Hospital, London

Dr Dick Fowler, Warden of the Royal College of Radiologists

Dr Christine Heron, Chair of the Royal College of Radiologists curriculum subcommittee