Delivering Cardiovascular Magnetic Resonance In the UK. BSCMR/BSCI guidelines

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1. Introduction: CMR in the UK

The management of cardiovascular disease (CVD) is rapidly changing, a trend likely to continue over the next decade. In parallel to the development of new, sometimes expensive treatments has the recognition that therapy (surgery, stenting, devices) should be better targeted to those patients who will benefit most. One key technology that aids this, and thus resource utilisation, is cardiovascular magnetic resonance (CMR).

CMR is an advanced form of Magnetic Resonance Imaging utilising ECG gating to avoid cardiac motion blurring. It allows assessment of anatomy, function and viability of the heart, but also can detect ischaemia & infarction, assess congenital heart disease, heart valve dysfunction and the presence of inherited diseases.

For many conditions, CMR is the gold standard test with an extensive and growing evidence base. It is safe (non-invasive, using no ionising radiation), accurate, provides prognostic evidence[1], changes patient management and reduces the need for other tests.[2]

CMR is supported by European and US consensus panel reports,[3,4] and is considered appropriate for the majority of indications - particularly for complex patient presentations where clinical suspicion is high. The British Cardiovascular Society report[5] on the future of cardiology over the next 10 years stated that CMR is the investigation likely to undergo the largest expansion of all imaging modalities. In 2007, two technology summaries by the National Horizon Scanning Centre[6,7] suggested CMR was an important advance and may become the gold standard for assessing myocardial viability and the preferred option for perfusion imaging. The caveat was that CMR capability would need to be expanded through training and capital investment. The National Heart Director has expressed an ambition to see a dedicated CMR scanner at every tertiary care centre in the country within 3-8 years, a goal not currently achieved. This is in line with the overall goal of the CHD National Service Framework which included the use of “appropriate investigations” of patients with suspected or established CHD.

This document outlines, as guidance:

a) the steps and standards that BSCMR/BSCI believe are necessary to deliver CMR nationally, achieving planned growth, co-ordinating capital planning etc
b) details of BSCMR/BSCI endorsement of individual, voluntary SCMR ‘accreditation’
c) details of a BSCI/BSCMR run proposed voluntary system of ‘CMR reference centres’ through the achievement of required standards of performance management, staffing and training.
d) appropriate training environments for trainees.

It draws on and references material from a number of organisations documented overleaf.

Note: BSCMR and BSCI support SCMR individual accreditation and do not separately accredit individuals. They do however advocate centers voluntarily choosing to apply for reference centre status through the achievement of a minimum standard.

A review date of this document has been set for March 2012.

Key resources used:

SCMR – The Society for Cardiovascular Magnetic Resonance, www.scmr.org
BSCMR - British Society of Cardiovascular Magnetic Resonance, www.bscmr.org
BSCI – British Society of Cardiovascular Imaging, www.bsci.org.uk
ESC - European Society of Cardiology, Working Group on CMR, www.escardio.org
RCR – The Royal College of Radiologists, www.rcr.ac.uk
Joint society 2006 Appropriateness Criteria for Cardiac Computed Tomography and CMR, http://content.onlinejacc.org/cgi/reprint/48/7/1475.pdf
NICE – National Institute for Health and Clinical Excellence, draft guidelines for imaging appropriateness, www.nice.org.uk
BCIS – British Cardiovascular Intervention Society, www.bcis.org.uk
BNCS – British Nuclear Cardiology Society, www.bncs.org.uk
BSE – British Society of Echocardiography, www.bsecho.org.uk,
NSCG, National Specialised Commissioning Group, Specialised services National Definitions Set 13, http://www.nscg.nhs.uk/index.php/key-documents/nationally-commissioned-specialised-services/
Cardiology Specialty Training Curriculum, www.jrcptb.org.uk/Specialty/Pages/Cardiology.aspx
MHRA, Medicines and Healthcare products Regulatory Agency, www.mhra.org.uk
IPEM, Institute for Physics and Engineering in Medicine, Magnetic Resonance Special Interest Group.

2. National Provision of CMR

2.1 Number of centres:

CMR is a specialised service, as defined by the specialised services national definitions set (third edition 2008). The number of CMR centres needed within the UK falls between limits defined by the need for a centre to have a sufficient volume of activity to develop and maintain expertise and the need for the service to be near the patient. Currently, there are approximately 30, CMR centres in the UK, 11 of which have scanners predominantly for CMR, a number which is currently growing. BSCMR/BSCI consider that, as a minimum, every cardio-thoracic centre in the UK should have access to CMR (42 centres), and as a maximum, based on the activity outlined below, there should be no more than 50 CMR centres.

2.2 Number of scans:

Estimating the requirement for CMR scans in the UK per annum is difficult but some estimate is necessary for service planning. We estimate the following requirements over the next 5 years – although this will initially need to be re-appraised annually given the rapid changes in the field:

a) Perfusion and viability – NICE (TA73) suggest that the UK need is for 4000/million/annum SPECT scans.[8] Several UK centres have switched to CMR and no longer perform nuclear studies. Evidence suggests that CMR is equivalent and in some circumstances better than nuclear scanning with no use of ionising radiation.[9] Accordingly, we estimate that 30% of the above scans will be done using CMR for the assessment of ischaemia and/or viability.
1,200 scans per million
b) Cardiomyopathy: with 340,000 inherited cardiovascular condition patients in the UK, 220,000 once familial hypercholesterolemia is excluded, demand can be considered as half of all new patients (New patients: 10,000 per year, 50% need CMR = 5000 per year) and half of all follow-up patients every 5 years (22,000, less new patients - 21,000 per annum); total 26,000 per annum.
520/million/annum
- c) GUCH growing
100 scans per million per year
- d) all other scan indications (aortas, valves, pericardium, poor echo windows EP etc). These constitute a major CMR workload, in the largest survey (the German registry), 20% of the workload, i.e.25% more than the above.
455 scans per million

Accordingly, the total BSCMR/BSCI estimated CMR need is 2275 scans per million adults per year, approximately equivalent to 52 full time CMR magnets doing 2250 scans per year in the UK.

3. Criteria for an Institution

To deliver consistent high quality CMR requires appropriate equipment, staff, and throughput. BSCMR/BSCI believes that service quality is related to training and individual procedure numbers and follows national and international guidelines for these. In addition, the committee also supports a minimum number of procedures per annum per institution and recommends CMR centres strive to become 'reference centres' and the full integration of CMR into clinical practice with strategies to ensure individuals do not work in isolation.

As a minimum, a CMR unit requires the following:

3.1. Equipment

MRI scanner

- A fully maintained, shared or dedicated MRI scanner (minimum 1.5 Tesla) with cardiac capability
- Sufficient magnet access to achieve minimum annual unit numbers
- Procedures in place to ensure a safe environment and quality (see later)
- ECG gating, patient monitoring (including BP, oxygen sats)

For a new CMR installation, BSCMR recommendations are:

- RF receiver: should comprise 16 or more RF channels (torso/body/cardiac receiver array with multiple elements).
- Gradient specifications: 30mT/m, 150mT/m/msec
- Artefact resistant ECG hardware/software (e.g. vectorcardiogram)

Specific cardiac sequences

- the minimum is:
  - SSFP cine imaging (bFFE, FIESTA or TrueFISP)
  - Black blood prepared T1/T2W TSE sequences with/without fat sat
  - Single shot black blood prepared TSE sequences (e.g. HASTE)
  - Phase contrast Flow/velocity sequences with quantification
  - Large vessel angiography
  - Late Gadolinium Enhancement imaging
- recommended is
  - realtime cine sequence
  - Perfusion sequences
  - Alternative late enhancement sequences (3D, PSIR, IR_SSFP)
  - 3D whole heart
  - other sequences (STIR, tagging, coronary sequence, cardiac iron)

Specialist software for analysis

- the minimum is:
  - Volumetric quantification of LV/RV volumes and mass
  - Quantification of velocity and flow
  - 3D angiographic reconstruction with respiratory compensation
- additional software may include:
  - complex 3D angiographic reconstruction, perfusion quantification, late enhancement quantification, LV analysis with long axis function, tagging analysis.

Other equipment

Resuscitation facilities (including defibrillation/oxygen/suction),
An emergency trolley with specific drugs to deal with potential reactions to iv contrast media and stressors.[10]
MR safe wheelchair & trolley,
MR compatible monitoring equipment such as: non-invasive blood pressure and SpO2 monitoring equipment
MR compatible power injectors and infusion pumps

3.2. Staff

A unit should have:

- a nominated Director with appropriate training, accreditation and CME/CPD, who is on the UK Specialist Register for Cardiology, Radiology, Nuclear Medicine or who is subspecialty accredited in CMR.
- a nominated Superintendent with appropriate training, responsible for (or delegating) equipment management and maintenance.
- appropriately trained medical and technical staff to deliver the service
- arrangements for scientific and technical input from a medical physics expert appropriately trained in CMR methods.
- arrangements for appropriate staff development, (education, training, accreditation, CPD, revalidation)
- current or planned (within 3 years) total activity sufficient to maintain individual accreditation

BSCMR recommend that where a Cardiology or Radiology CMR senior appointment is made, where equipment is to be shared, the appointment panels have representation from both Cardiology and Radiology.

3.3. Scanning

Patient confidentiality must be maintained at all times.

- Units should base their scan protocols on internationally agreed scanning protocols (SCMR protocols)[11]
-have a clear standard operating procedure for deviation from SCMR protocol
- at least 2 members of staff must be present during scanning, both of whom must be trained in magnet safety, and at least one of whom should be appropriately trained in CMR scanning. For stress imaging, at least one available member of staff must be medically trained and up-to-date to deal with potential complications (including a valid ALS or ILS qualification).

3.4. Reporting

All clinical CMR scans should have a report generated. Responsibility for CMR reports always lies with a consultant. No reports should be signed off without it being clear who this is. However, as with echocardiography and general radiology, it is possible that reporting can be delegated by the consultant under the following conditions:

- A level 3 CMR accredited physician should be available to discuss cases when needed.
- The reporter is a trainee at level 2 or above.

CMR reporting should be clinically integrated with scan result availability at multidisciplinary review at least fortnightly. CMR practitioners should avoid reporting in isolation. Should only one reporting level 3 physician be present in a unit, that unit should aim for a link-up with a separate centre or reporting physician at least six times a year.

CMR reports should conform to appropriate national standards,[12] and/or adjust international reporting standards to local UK needs.[13]

When reporting, all areas of all images should be reviewed – including scout images and any extra-cardiac areas cropped out by some viewing software. This includes when the aim of imaging is designed for import into other systems (eg atrial angiograms for electrophysiology procedures, stent design).

Where a cardiologist/nuclear physician is reporting alone, radiology advice should be available to discuss extra-cardiac pathology; similarly expert cardiology advice should be available for discussion of findings in radiology based services.

3.5. Quality control

The quality assurance programme should be defined in a written policy with regular audit of all policies and procedures. Radiographers/technologists and medical physics staff must be fully involved in this process with appropriate analysis and monitoring of the data obtained. Guidance relating the quality control measures has been provided by the Institute of Physics and Engineering in Medicine (IPEM).[14]

A written policy should be in place for CMR equipment image quality testing. Signal and geometric parameters should be monitored. Information, will be provided by the MR safety advisor or medical physics expert in MRI.

The unit must have an effective framework for the safe use of the MR equipment. Detailed guidance is available in the MHRA Device Bulletin, DB2007, Dec 2007: Safety Guidelines for Magnetic Resonance Imaging Equipment in Clinical Use.[15] These guidelines cover all aspects of safety including unit design and maintenance.

Each unit should have a specified MR responsible person (in most cases the director or the superintendent radiographer of the unit) who is in charge of MR safety. The MR responsible person should work closely with a MR safety advisor, a clinical scientist with MR physics expertise, who should advise on necessary engineering, scientific and administrative aspects of the safe use of MR.

3.6. Emergency procedures

Emergency procedures should be reviewed and audited at regular intervals

- Cardiac arrest
- Fire
- Magnet quench
- Decreased oxygen level
- Power loss / loss of lighting

Details are outlined in the MHRA guidelines DB2007(3) and are applicable to all clinical MRI units.

3.7. Exposure (SAR) limits:

RF exposure for most routine clinical scans should fall within an uncontrolled or upper level scanning mode. All scans incurring an experimental mode of exposure (i.e. controlled mode scanning) must have ethical approval. Scanning pregnant patients should be considered on a risk/benefit basis. Detailed information is available from the MHRA guidelines DB2007 (3). Exposure limits are similar for all clinical MRI units.

3.8. Audit and discrepancy meetings

Departments should undergo regular audit as part of the clinical governance of the service. Although at this stage, national and international guidelines and audit standards are poorly developed, specific areas for attention may include those where interpretation may be particularly complex, for example perfusion CMR, ARVC, dobutamine stress and congenital heart disease. BSCMR/BSCI also recommend regular patients' view audit, as recommended in the RCR auditlive website

A reporting discrepancy occurs when a retrospective review, or subsequent information about patient outcome, leads to an opinion different from that expressed in the original report. Not all reporting discrepancies are errors. BSCMR recommends discrepancy meetings ~4 times a year, either separately, as part of 'hits and misses' meeting or as part of a multimodality imaging meetings or audit meetings. The purpose of these is to facilitate collective learning thereby improving patient safety. They do require sensitive handling and specific, detailed guidance exists from the Royal College of Radiologists on them. Such meetings form an important part of the audit process and the structure of these meetings must ensure a blame-free learning orientated environment. [16]

4 Unit annual numbers and CMR reference centres

CMR requires a high degree of operator input and expertise during scanning. The diverse nature of clinical indications and findings in clinical context means that CMR reporting benefits from minimum numbers to maintain quality and competency, even in trained staff.

BSCMR/BSCI recommend that Institutional CMR numbers are a minimum of 300 cases per annum, and more than 500 cases per annum for training centres. In centres performing under 500 cases per year, level 1 (core) training can be performed, as can some advance modules/sub-specialty training – but the advanced module/sub-speciality trainee will require additional experience at an accredited training centre for at least one year (half of their advanced modules/sub-specialty training).

Should a centre not be performing 300 cases per year, then:

- robust plans should be in place to achieve this minimum standard within 3 years including a formal link-up with a high volume centre which should be effected to ensure consistent quality until 300 scans per annum are being performed – and preferably continuing afterwards.
- If 300 cases per year cannot be achieved within 3 years, the centre stops CMR scanning and transfers the activity to a high volume centre.

Less than 300 cases per year is acceptable for a site where an established CMR team do outreach lists, in which case this activity should be considered as part of the main sites activity.

4.1 CMR reference centres*

BSCMR/BSCI recommends centres aim to become ‘reference centres’,.* This is a voluntary process but represents a standard that the NHS can take for commissioning purposes. The title of ‘reference centre’ is attached to a named unit and Director and is recommended within 3 years of an institution commencing scanning. This service is provided by BSCMR/BSCI as part of their society objectives and is free of charge provided the applicant (unit director) is a society member. It is not meant to be arduous, bureaucratic or restrictive and consists of the following 3 types of information:

1. Written confirmation of appropriate equipment and trained staff.
2. Central (BSCMR/BSCI subcommittee) review of the images of any ten cases submitted from the unit, the cases representing at least five pathologies out of the 14 referenced in SMCR standard protocols (see appendix 1).
3. Central (BSCMR/BSCI subcommittee) review of the reports of the above cases.

It is expected that such centres will have, in addition: a) access to educational material, b) journal clubs, c) interesting case reviews and d) research opportunities for trainees – although these are not formally assessed as part of accreditation.

For further details of becoming a CMR reference centre, see appendix 1
One duty that goes with becoming a reference centre is the submission of an annual return to BSCMR/BSCI. This return will relate to unit activity, growth, trainees allowing BSCMR/BSCI to provide activity statistics to help Department of Health planning and CMR service delivery/commissioning. Re-registration as a reference centre is currently only advised if a unit undergoes major restructuring (eg change of site or unit director). Contact BSCMR or BSCI by email for more detail.

*when drafting this report, 'centre accreditation' was proposed. However, 'accreditation' has specific legal connotations, so BSCMR focuses on 'reference centres'.

5. Individual training, accreditation and CPD

CMR is an expanding and fast developing field. Therefore, training of staff and maintenance of up-to-date CMR practice is an important part of delivering a quality service.

5.1 Initial Training

BSCMR/BSCI follow SCMR guidelines.

- Technologists:
  - At least 6 months of full-time experience in MR (at a center performing >300 CMR cases/year) or 12 months of training if the facility performs between 50-300 CMR exams per year. (www.scmr.org in preparation)
  - At least 30 hours of CMR-related coursework.

Coursework must be completed at the university level, accredited CME/CEU programs, or accredited CMR training programs. Recognized registered MRI Technologists maybe exempt from these requirements upon successful documentation of previous work.

5.2. Individual Physician Accreditation/Certification:

The Director of the CMR lab:

- must hold one of: SCMR Level 3 accreditation,[17,18] completed advanced modules (formerly know as sub-specialty training) in CMR and or subspecialty degree (advanced modules) in cardiac radiology or equivalent
- be a consultant with CCT in cardiology or radiology, who is on the UK Specialist Register and is revalidated/licensed to practice CMR in the UK, once licensing is introduced

CMR training is now coded nationally and internationally. Please see the cardiology[19] and radiology[20] higher specialist training curricula (formerly know as sub-specialty curricula), BSCMR guidelines and SCMR guidelines.[21] At the time of writing, there are minor differences between these requirements; BSCMR is in the process of adjusting its recommendations to be aligned with SCMR guidelines. Although completion of UK training results in entry onto the specialist registry, BSCMR/BSCI in addition supports the SCMR concept of level 1,2 and 3 training with level 1 being equivalent to core training, level 3 to completed advanced modules/higher specialist training, and level 2 permitting independent magnet operation and delegated reporting. BSCMR/BSCI recommend that for advanced modules/specialist training, at least half of such training should be done in a high volume (>500 cases per year) centre. CMR training is based on competency assessment, time in training, didactic and self directed study and scan numbers. For cross comparison, the table below shows comparisons with other cardiac imaging modalities. *BSCMR/BSCI do not accredit individuals independently of SCMR*

Comparison with other imaging modalities

technique	Level I	Level II	Level III	Maintenance
CMR[*]	50	150	100 performed, (300 total interpreted)	200 +CPD 40hrs per 2 years.
Echo[§] (transthoracic)	75 performed (150 interpreted)	150 performed (300 interpreted)	300 performed (750 interpreted)	100 pa + CPD or 250 pa
Nuclear[†]	100	300	600	
CT (coronary)[†]	50	150 non-contrast, 150 with contrast	300 with contrast 100 non-contrast	
Coronary Angiography[††]	100 (participated)	300 (participated)	250 interventions (participated)	125 pa 75 with plan to grow to 150 for PCI

[*]Kim RJ et al. Guidelines for Training in CMR. JCMR 2007;9:3–4
[§]ACC/AHA Clinical Competence Statement on Echocardiography. A Report of the American College of Cardiology/American Heart Association/American College of Physicians–American Society of Internal Medicine Task Force on Clinical Competence. JACC 2003;41:687–708
[†]Cerqueira MD et al. Task Force 5: Training in Nuclear Cardiology. JACC 2006: 898–904
[†]ACC and ACR Training Competency Requirements for Cardiac CT.
[††]Jacobs AK et al. Task Force 3: Training in Diagnostic and Interventional Cardiac Catheterization. JACC 2008;51:355-61

5.3. Revalidation and CPD:

The CMR physician will be required to maintain competence including revalidation. For level 2 and 3 accreditation, the SCMR requirements are currently: [22]

- Level II: 20 hours of coursework and primary interpretation of 100 cases every two years.
- Level III: Forty hours of coursework and primary interpretation of 200 cases every two years.[23]

Appendix 1

Becoming a CMR reference centre:

This voluntary process consists of 3 elements: written confirmation of appropriate equipment and trained staff; Central sample image review and central review of the reports of the same images. It also requires an annual return on CMR scanning activity.

For the central image review, 10 scans including at least 5 of the following scan types should be sent to BSCMR/BSCI. These topics are the headings from the SCMR standardized scanning protocols.

1. Acute myocardial infarction (MI)
2. Chronic ischemic heart disease and viability
3. Dobutamine stress
4. Adenosine stress perfusion
5. Peripheral magnetic resonance angiography (MRA)
6. Thoracic MRA
7. Anomalous coronary arteries
8. Pulmonary vein evaluation
9. Non-ischemic Cardiomyopathy
10. Arrhythmogenic right ventricular cardiomyopathy (ARVC)
11. Congenital heart disease
12. Valvular heart disease
13. Pericardial disease
14. Masses

Image transfer can be via CD or webpax or the NHS secure image transfer system. If anonymised via webpax, the reports must have the institute details and date scanned. The images should be accompanied by their report.

The standard for judging submitted cases images and reports is the SCMR standardized protocols/reporting recommendations. The assessment panel should, if possible, have representation from BSCI and BSCMR. It is recognised that it may be entirely appropriate to depart from these standards and this is acceptable provided this is acknowledged in the submission. Should any cases/reports be considered inadequate, cases may be resubmitted by the centre. Dispute will be resolved by the president(s) of BSCMR/BSCI in consultation. Reference centre renewal is currently only required/advised if a unit undergoes major restructuring (eg change of site or unit director). Enquiries via BSCMR by email for more detail.

Appendix 2

Writing group and approval process of this document:

This document was first drafted a writing group for the board of BSCMR, then it was reviewed by the board of BSCI and submitted for review by the Cardiac imaging council, a part of the British Cardiac Society. The writing team were Dr James Moon, Dr Anna Herrey and Professor Stefan Neubauer.
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