

Training and accreditation in cardiovascular magnetic resonance in Europe: a position statement of the working group on cardiovascular magnetic resonance of the European Society of Cardiology

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Received 12 March 2010; revised 19 October 2010; accepted 2 December 2010; online publish-ahead-of-print 2 February 2011

Background

Cardiovascular magnetic resonance (CMR) has become an established imaging modality which provides often unique information on a wide range of cardiovascular diseases. The European Society of Cardiology (ESC) training curriculum reflects the emerging role of CMR by recommending that all trainees obtain a minimum level of training in CMR and by defining criteria for subspecialty training in CMR.¹ The wider use of CMR requires the definition of standards for data acquisition, reporting, and training in CMR across Europe. At the same time, training and accreditation in all cardiac imaging methods should be harmonized and integrated to promote the training of cardiac imaging specialists. The recommendations presented in this document are intended to inform the discussion about standards for accreditation and certification in CMR in Europe and the discussion on integrated imaging training. At present, the recommendations in this position statement are not to be interpreted as guidelines. Until such guidelines are available and nationally ratified, physicians will be able to train and practice CMR according to current national regulations.

Aims

This document has been prepared by the working group (WG) on CMR of the ESC. It aims to make proposals for a European

standard for competency and excellence in CMR acquisition and reporting. This is to be achieved by providing recommendations for training of individuals wishing to perform and report CMR studies as well as for the accreditation of centres performing CMR studies and wishing to offer CMR training. The document has been written in concordance with the ESC processes on accreditation and certification. However, it is emphasized that European certification of CMR competency or institutional accreditation in CMR as outlined in this document are not compulsory or regulatory certificates. An individual's right to report and sign clinical studies and an institution's right to provide a CMR service in individual countries remain defined by National laws and regulations.

These processes have been synchronized as much as possible with other recommendations for CMR training such as the Core Cardiology Curriculum of the ESC,¹ those guidelines of the Society for Cardiovascular Magnetic Resonance (SCMR),² and the European Association of Echocardiography.³

The WG recognizes that physicians who have completed their specialty training and hold a licence to practice medicine face different constraints than trainees and it will often be impractical for them to spend prolonged periods away from their place of work. These recommendations therefore include alternative training options for licensed physicians.

The opinions expressed in this article are not necessarily those of the Editors of the *European Heart Journal* or of the European Society of Cardiology.

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Individual certification

Who benefits from obtaining European certification of cardiovascular magnetic resonance competency?

- The goal of certifying individuals is to set a European standard for competency and excellence in CMR acquisition and reporting.
- Certification in CMR will bring credibility and professional legitimacy to an individual wishing to practice CMR.
- Certification of competency in CMR can be obtained at three levels, reflecting the different training needs between general cardiologists and those with a subspecialty interest in imaging;
 - Level 1 competency is the most basic level and reflects core CMR training that should be obtained by all cardiology trainees according to the ESC Core Cardiology Curriculum.
 - Level 2 competency is the level required for an individual wishing to report CMR studies—with local or remote support from a Level 3 certified individual. Certification of Level 2 competency fulfils the requirement of sub-specialty training in cardiac imaging as set out in the ESC curricula.
 - Level 3 competency is required for individuals wishing to perform, interpret, and report CMR studies fully independently, to lead a CMR laboratory and to supervise CMR training programmes in an accredited CMR training centre.
- European certification of CMR competency is not a compulsory or regulatory certificate. At present, an individual's right to report and sign clinical studies in individual countries are defined by National laws and regulations.

Requirements for cardiovascular magnetic resonance competency

Level 1

Level 1 competency in CMR is a core component of the Cardiology Curriculum of the ESC.¹ This level of competency represents basic background knowledge in CMR sufficient to select the appropriate CMR indications for patients with known or suspected cardiovascular diseases and interpret CMR reports in the clinical context. Level 1 competency is not sufficient for the practice or independent clinical interpretation of CMR. The WG recommends that Level 1 competency in CMR requires:

- (a) A documented involvement in 50 CMR cases and a full-time attachment of 1 month (or the equivalent distributed over up to 6 months) to an accredited CMR institution or under the guidance of a Level 3 accredited CMR expert. For physicians who hold specialty certification, a more flexible training plan can be agreed between the trainer and the candidate. This should contain a minimum of 2 weeks on site training and can include up to 2 weeks remote training. The use of training databases or case-study collections is encouraged.
- (b) Attendance to departmental or other teaching events to understand basic CMR physics and clinical use of CMR, common protocols, costs, artefacts, indications, contraindications, and pitfalls (20 CME hours). See Appendix 1 for required course topics.

Level 2

Certification of Level 2 competency in CMR is aimed at individuals who wish to sub-specialize in cardiac imaging and who want to actively perform and report CMR under the supervision of a Level 3 accredited expert. The supervising Level 3 expert must either work in the same institution or offer remote support for all aspects related to CMR scanning and reporting. The WG recommends that Level 2 certification should only be issued after completion of specialty training and that the formal certification process consists of three parts, which must all be completed:

- (a) Lectures and courses: course work to include more advanced lectures and reading materials than for Level 1 and to continue for the duration of the traineeship (at least 50 CME hours). Training must also include at least one organized CMR teaching course.
- (b) Training in an accredited centre: Level 2 certification can be acquired in a minimum of 3 months spent in an accredited institution under the guidance of a Level 3 accredited CMR expert. Training does not have to be consecutive, but has to fall within a 2-year period. All candidates must submit a logbook of 150 clinical cases.
- (c) Written exam: candidates must pass the European CMR exam.

(a) *Lectures and courses.* Level 2 certification should include formal teaching events to understand basic CMR physics and clinical use of CMR, common protocols, costs, artefacts, indications, contraindications, and pitfalls. All ESC-endorsed CMR teaching courses, which cover the physics and clinical application of CMR (such as the course organized by the WG, www.CMR-course.de), or other courses or training programmes that provide at least 50 h of CME in CMR are recognized for this purpose. For recommended course topics see Appendix 1.

(b) *Training in an accredited centre.* Candidates should prepare a log book consisting of 150 anonymized CMR studies accrued over a 12-month period (from 1 year before until 1 year after passing the written exam). The candidate should have been present during the acquisition of at least 50 of the cases. At least 50 studies should be primarily reported by the candidate. The log book should be written in English.

The following categories of pathology/clinical assessment should be included in the log book:

- detection of myocardial infarction and assessment of viability;
- stress testing with either vasodilator or staged inotropic stress (at least 25 cases);
- left and right ventricular function assessment;
- aortic, mitral, tricuspid, and pulmonary valve pathology;
- aortic pathology including dilatation and dissection;
- common basic congenital heart disease (CHD) and adult CHD (ACHD) (such as coarctation of the aorta, post-operative Tetralogy of Fallot, intracardiac shunts, coronary anomalies) (at least 25 cases);
- assessment of causation of heart failure;
- assessment of cardiomyopathy phenotype including hypertrophic cardiomyopathy, arrhythmogenic right ventricular cardiomyopathy, dilated cardiomyopathy;
- pericardial abnormality;

- cardiac mass/tumour;
- angiography of major arteries including aorta, pulmonary, carotid, and renal.

Where not all of these indications can be obtained in a particular training centre, the candidate should endeavour to receive specific training in another accredited centre. If this cannot be achieved, cases or teaching files from other centres can be used—but not for more than 100 cases.

Teaching must take place in an accredited CMR Institution (see Aims section). However, the WG recognizes that institutional accreditation is a new concept, and recommends that for an interim period training under the auspices of a Level 3 accredited individual in a non-accredited institution is accepted.

Because many CMR studies are performed during pharmacological stress, the WG regards it as an essential requirement of CMR accreditation that an individual wishing to supervise CMR studies is trained in Basic Cardio-Pulmonary life support (BCLS) and Advanced Cardio-Pulmonary life support (ACLS). This can be obtained from any accredited ACLS training centre, often within the host institution or can be part of a clinical training programme.

Documents to submit with the log book:

- Summary sheet.
- Letter from a supervisor testifying that the studies were performed and reported by the candidate.
- Letter from the supervisor documenting training and the review of studies undertaken by the candidate.
- Supervisor enrolment form.
- BCLS and ACLS documentation.
- Copies of relevant board certifications and licences.

(c) *The written exam.* A written exam is to be held under the auspices of an independent ESC-appointed authority. The exam consists of a theoretical and a clinical case reporting part. Both parts of the examination have to be passed to be successful in the examination. If Level 2 accreditation has not been achieved within 5 years of taking the examination, the exam has to be repeated.

Re-certification

It is recommended that following certification, Level 2 accredited individuals maintain their skills by documentation of at least 20 h of CME in CMR every 3 years plus the documented attendance during and the primary reporting of at least 100 CMR studies every 3 years. These cases may not be taken from a database.

Level 3

Certification of Level 3 CMR competency represents the highest level of expertise and would enable an individual to pursue a clinical or academic career in CMR, to direct a CMR laboratory and act as an accredited CMR trainer in an accredited CMR training centre. In addition to the recommendation for Level 2, Level 3 competency should reflect more in-depth and structured training and supervised interpretation of at least 300 CMR cases. As for level 2, the WG recommends certification should only be issued after completion of specialty training and that the formal

certification process consists of three parts, which must all be completed:

- (a) Lectures and courses: at least 50 CME hours over no more than 2 years including at least one organized CMR teaching course.
- (b) Training in an accredited centre: Level 3 certification can be acquired over a 12-month period with a log book of 300 clinical cases.
- (c) Written exam: candidates must pass the European CMR exam.

(a) *Lectures and courses.* At least 50 CME accredited hours of CMR training should be attended within a period of 2 years. In addition, training in the accrediting centre should include a structured teaching programme covering in detail MR physics, clinical indications, and image interpretation. See Appendix 1 for recommended course topics. Training must also include at least one organized CMR teaching course.

(b) *Training in an accredited centre.* For Level 3 certification, candidates should keep a log book consisting of 300 anonymized CMR studies accrued over a 12-month period (from 1 year before until 1 year after passing the written exam). The candidate should have been present during the scan and be involved in the acquisition and the primary interpretation of at least 100 CMR cases. In the remaining 200 cases, the trainee should review at least 100 of these cases with the Level 3 mentor. The log book should be written in English.

The following categories of pathology/clinical assessment should be included in the log book:

- detection of myocardial infarction and assessment of viability;
- stress testing with either vasodilator or staged inotropic stress (at least 50);
- left and right ventricular function assessment;
- aortic, mitral, tricuspid, and pulmonary valve pathology;
- aortic pathology including dilatation and dissection;
- common basic CHD and ACHD (such as coarctation of the aorta, post-operative Tetralogy of Fallot, intracardiac shunts, coronary anomalies) (at least 50 cases);
- assessment of causation of heart failure;
- assessment of cardiomyopathy phenotype including hypertrophic cardiomyopathy, arrhythmogenic right ventricular cardiomyopathy, dilated cardiomyopathy;
- pericardial abnormality;
- cardiac mass/tumour;
- angiography of major arteries including aorta, pulmonary, carotid, and renal.

Where not all of these indications can be obtained in a particular training centre, the candidate should endeavour to receive specific training in another accredited centre. If this cannot be achieved, cases or teaching files from other centres can be used, but not for more than 200 cases.

Teaching must take place in an accredited CMR Institution (see Aims section). However, the WG recognizes that institutional accreditation is a new concept, and recommends that for an interim period, training under the auspices of a Level 3 accredited individual in a non-accredited institution is accepted.

Because many CMR studies are performed during pharmacological stress, the WG regards it as an essential requirement of CMR accreditation that an individual wishing to supervise CMR studies is trained in BCLS and ACLS. This can be obtained from any accredited ACLS training centre, often within the host institution or can be part of a clinical training programme.

It is expected that the individual participates in an ongoing quality assurance or improvement programme for the laboratory or facility in which he or she is associated.

Documents to submit with the log book:

- Summary sheet.
- Letter from a supervisor testifying that the studies were performed and reported by the candidate.
- Letter from the supervisor documenting training and the review of studies undertaken by the candidate.
- Supervisor enrolment form.
- Basic and Advanced Cardiac Life Support documentation.
- Copies of relevant board certifications and licences.
- Evidence of participation in a quality assurance or improvement programme.

(c) *The written exam.* The CMR exam is mandatory for Level 3. If it has been passed as part of Level 2 certification, the exam does not need to be repeated to obtain Level 3 accreditation. If an individual applies directly for Level 3 certification without preceding Level 2 certification, the exam is mandatory and Level 3 accreditation must be achieved within 5 years of taking the examination.

Re-certification

It is recommended that following certification, Level 3 accredited individuals maintain their skills by documentation of at least 40 h of CME in CMR every 3 years plus the acquisition and primary reporting of at least 200 CMR studies every 3 years. These cases cannot be taken from a database. It is also recommended that they participate in an active training programme either in their own institution or by contribution to national or international educational activities in CMR.

Table 1 summarizes the training requirements for the three levels of certification.

Table 1 Summary of recommendations for individual certification in cardiovascular magnetic resonance

Level	Duration of training	Cases	CMR exam	CME (h)	Other
1	1 month	50+	No	20	
2	3 months (can be split)	150+ (log book)	Yes	50	BCLS, ACLS
3	12 months (can be split)	300+ (log book)	Yes	50	BCLS, ACLS

BCLS, Basic Cardiac Life Support; ACLS, Advanced Cardiac Life Support.

Training in cardiovascular magnetic resonance of congenital and adult congenital heart disease

The WG considers CMR in CHD and ACHD to be subspecialty qualifications beyond the scope of this document. This view is consistent with recommendations by other ESC WGs and associations.^{4,5} However, all individuals seeking training in CMR need to be aware of the common indications of CMR in CHD and ACHD. In addition, Level 2 and Level 3 training in CMR must include exposure to some CMR studies in CHD and ACHD so that trained individuals can recognize these conditions and refer to a specialist if required. The WG considers 25 (for Level 2) or 50 (for Level 3) to be the minimal number of cases required.

Institutional accreditation

The aim of institutional accreditation in CMR is to harmonize standards across the European Community and to ensure the quality of training in CMR. The difficulties associated with accrediting institutions for CMR are recognized but the WG firmly expects that this process is necessary to maintain standards during the expected expansion of CMR services across Europe. The proposals for an accreditation process links with other core initiatives of the WG, in particular individual certification and the EuroCMR registry. The proposals for institutional accreditation set out in this document should be achievable by most institutions performing CMR on a regular basis.

Which institutions will benefit from obtaining European cardiovascular magnetic resonance accreditation?

- The goals of institutional accreditation are to set a European standard for the practice of CMR and for the institutional training of individuals in CMR.
- European CMR accreditation will bring credibility and legitimacy to an institution wishing to perform CMR studies and to train individuals in CMR and demonstrates commitment to quality care.
- In an increasingly competitive environment, site accreditation will give an advantage to institutions in negotiations with health care funders.
- Accreditation can be linked to the EuroCMR registry, giving the opportunity for confidential peer-review and quality control.
- Accreditation in CMR for institutions is not a compulsory or regulatory certificate of competence or excellence and does not cover any aspects of MR safety. At present, all of these remain to be defined by National laws and regulations.
- SCMR accredited sites can apply for automatic European CMR accreditation at no additional cost.

Requirements

Institutional accreditation in CMR should include the following:

- (a) Case load: institutions need to perform at least 400 CMR studies per year.

- (b) Case mix: a wide case mix has to be covered at the institution, following the recommendations for the log book for individual accreditation.
- (c) Supervision: the institution is led by qualified supervisors (ESC Level 3, SCMR Level 3, or equivalent national accreditation). Clinical cases are reviewed with trainees in a regular scheduled reporting session.
- (d) Structured training programme: regular audit and teaching is provided (at least one scheduled teaching session per week). Teaching covers all aspects of CMR, including Physics and practical scanning.
- (e) Safety of CMR studies: because of the general increase in referrals for CMR studies requiring pharmacological stress, the WG regards it as essential that accredited CMR sites demonstrate they have procedures in place to respond rapidly and appropriately to common cardiovascular emergencies such as cardiac arrhythmia, cardiogenic shock, and respiratory failure. This recommendation is in accordance with the guidelines for stress echocardiography by the European Association for Echocardiography.⁶ Institutions need to show that;
 - They have standard operating procedures in place for the safe and rapid removal of patients from the magnet into an appropriate resuscitation area (the WG recommends that this takes no more than 1 min).
 - They have the necessary equipment to deal with common emergencies (including specifically an external cardiac defibrillator, emergency drugs, high flow oxygen, and intubation instrumentation).
 - Evacuation and resuscitation procedures are rehearsed at least every 6 months and that new members of staff are trained before they can actively participate in stress studies.
 - Staff performing CMR studies is trained in ACLS and that trained personnel is present in the department during studies involving pharmacological stress.
- (f) MR safety: the WG recognizes that there is currently no Europe-wide guideline on requirements for the safe operation of magnetic resonance facilities. Such guidelines are in preparation and once available will become a requirement for site accreditation. In the meantime, the WG recommends that sites demonstrate compliance with local or national safety guidance.
- (g) Quality-control: it is recommended that the institution participates in a peer-reviewed quality programme [such as the EuroCMR registry: www.herzinfarktforschung.de/Projekte/Registrier/EuroCMR.html]. We anticipate that participation in a formal quality control programme will become a mandatory requirement for site accreditation in the future.
- (h) Multi-modality imaging environment: the WG on CMR appreciates that CMR will in most institutions be available along with several other cardiovascular imaging modalities including echocardiography, invasive angiography, nuclear cardiology, cardiac computed tomography, and others. The structure and interaction of such multimodality imaging facilities need to be defined separately in future joint documents.

Institutional accreditation for cardiovascular magnetic resonance of congenital and adult congenital heart disease

The WG on CMR considers accreditation of institutions for CMR in CHD and ACHD to be outside the scope of this document. Consistent with recommendations by other ESC WGs and associations,^{4,5} centres wishing to perform these studies on a regular basis require subspecialty accreditation that is to be defined separately. However, all institutions seeking accreditation in CMR should demonstrate that common indications of CMR in CHD and ACHD can be recognized in the centre and are appropriately referred to a specialist centre if required.

Accreditation process

The following documents should be part of a request for site accreditation:

- Level 3 CMR certificate for at least one member of the institution.
- An outline of the CMR and multi-modality cardiovascular imaging training programme.
- A scan log of 400 cases performed in the previous 12 months.
- Standard operating procedures for dealing with cardiovascular emergencies.
- Demonstration of compliance with local or national MR safety guidelines.
- Recommended: demonstration of participation in a quality control programme.

Appendix 1

Topics for course work

Level 1

The trainee should develop a basic understanding of:

- (1) MR physics:
 - (a) the basics of physics of magnetic resonance as it relates to image intensity and contrast, including flow, T1, T2, density of nuclear species (e.g. proton), and contrast agents;
 - (b) the principles of common CMR methods, including cine imaging, velocity encoded CMR, black blood imaging, dynamic and late contrast enhanced imaging, and MR angiography.
- (2) Clinical use of CMR:
 - (a) clinical indications for CMR and the role of CMR compared with other imaging modalities;
 - (b) contraindications to CMR and safety issues, including safety of implanted devices (e.g. pacemakers, automatic implantable cardioverter-defibrillators), external ferromagnetic devices, and gadolinium-based contrast agents;
 - (c) Basic CMR protocols for common clinical indications;
 - (d) basic post-processing approaches and analyses.

Level 2

The above plus

- (1) Physics: trainees should receive didactic lectures from a CMR-trained physician (who has achieved Level 2 or 3 in CMR) and/or physicist on the basic physics of magnetic resonance in general and as it relates to CMR in particular. The content should include the same materials as in Level 1 (basic) plus lectures with supportive reading on the following topics:
 - (a) Image formation, including k-space, gradient echo, spin echo, fast spin echo, echo planar, spiral, steady state free precession (SSFP), and parallel imaging;
 - (b) Specialized imaging sequences, including flow and motion, phase imaging, time of flight, contrast agents, and radiofrequency tagging;
 - (c) Hardware components, including the elements of gradient coil design, receiver coils, and digital sampling;
 - (d) Sources of artefacts, including motion, arrhythmias, and metal objects.
- (2) Applications, interpretation, indications, and contraindications: Level 2 didactic activities should include an understanding of the sensitivity, specificity, accuracy, utility, costs, acquisition approaches, and disadvantages of all of the contemporary techniques in CMR. The following techniques should be covered in the didactic program:
 - (a) Imaging of structure and tissue characterization (T1, T2, spin echo, gradient echo, SSFP, image contrast mechanisms, and fat suppression);
 - (b) Imaging and analysis of cardiac function (cine and tagged cine magnetic resonance including SSFP imaging approaches);
 - (c) Volumetric imaging and measurement of mass, biventricular volumes, and ejection fraction (using cine magnetic resonance imaging);
 - (d) Flow imaging (e.g. velocity-encoded techniques) and analysis of flow-encoded images;
 - (e) Imaging of myocardial infarction, scarring, and viability assessment (delayed contrast-enhancement imaging);
 - (f) Pharmacologic stress testing with evaluation of ventricular function and/or first-pass perfusion imaging using a contrast agent;
 - (g) Magnetic resonance angiography (vascular);
 - (h) Imaging of the coronary arteries and classification of coronary anomalies;
 - (i) Imaging of valve pathology;
 - (j) CMR assessment of aortic pathology;
 - (k) Common basic CHD and ACHD (such as coarctation of the aorta, post-operative Tetralogy of Fallot, intracardiac shunts, coronary anomalies);

- (l) CMR imaging in heart failure.
- (m) CMR assessment of cardiomyopathy phenotype including hypertrophic cardiomyopathy, arrhythmogenic right ventricular cardiomyopathy, dilated cardiomyopathy;
- (n) Imaging of the pericardium with common pathologies;
- (o) Assessment of cardiac masses and tumours;
- (p) Mechanisms, types, and pharmacologic aspects of CMR contrast agents;
- (q) Electrocardiogram and peripheral pulse gating and triggering including timing of image acquisition within the R–R interval, motion artefacts, and their effects on CMR images; respiratory motion suppression methods (e.g. breath-holding and navigators);
- (r) CMR image analysis and post-processing tools;
- (s) Contraindications for CMR study;
- (t) Incidental findings suggesting pathology outside of the cardiovascular system.

Level 3

The above plus

- (1) An understanding of why certain specialized imaging sequences are applicable for specific clinical protocols, including imaging of heart function, coronary arteries, perfusion, delayed enhancement, and peripheral arteries.
- (2) Basic understanding of the clinically applicable spectroscopic methods.
- (3) The essentials of data collection, including capturing of digital data, the maintenance of accurate databases and records, signal processing, and the approaches for quantitative data analysis.

Conflict of interest: S.P. is supported by a Wellcome Trust Intermediate fellowship (WT078288).

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