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Core curriculum for the heart rhythm specialist†

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Heart rhythm (HR) management is rapidly developing as a subspecialty within cardiology and it is imperative to promote and ensure sufficient and homogeneous training and qualification among professionals in Europe. This encouraged the European Society of Cardiology, through the European Heart Rhythm Association (EHRA), to organize a European Core Curriculum for the HR specialist through the following: definition of the scope of the HR speciality (Syllabus), development of minimum standards and objectives for training in HR management (Curriculum), development of a model to certify HR professionals and teaching units (Accreditation), and development of a Registry for European HR accredited professionals and teaching units and their activity (Registries). The duration of the training period should be of a minimum of 2 years following general cardiology training. During this period, the trainee must develop the required knowledge, practical skills, behaviours, and attitudes to manage HR patients. The trainee must be involved in a minimum number of different procedures and achieve specified levels of competence. The training centre should be integrated within a full-service cardiology department. Assessment of the trainee and the training programmes should include reports by the training programme supervisor and the national society HR organizations, a logbook of procedures, written examinations, and assessment of professionalism. The EHRA presently requires the trainee to pass the EHRA accreditation exams (invasive EP and cardiac pacing and ICDs). Continuous learning and practice are required to maintain standards and practice because substantial changes may occur in clinical practice or the health-care environment.

Keywords Accreditation • Arrhythmia • Curriculum • Education • Electrophysiology • Heart rhythm

Table of Contents

Introduction

Heart rhythm (HR) management is rapidly developing as a subspecialty within cardiology that is devoted to the diagnosis and the treatment of cardiac rhythm disorders, including invasive evaluation of their mechanisms, controlled destruction of arrhythmogenic myocardium by percutaneous catheters, and implantation of cardiac rhythm management devices. Catheter ablation is the therapy of choice for most supraventricular tachycardias. More than 50 000 interventions are performed every year in Europe.[1] Device implantation for arrhythmia treatment, sudden death

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prevention, and cardiac resynchronization are practiced regularly nowadays, and are performed in more than 200 000 patients in Europe per year.[1] The increase in the indications and the number of all of these procedures depicts the present scenario by emerging indications, an increasing number of invasive procedures, and the establishment of new practising units and professionals. Nevertheless, these procedures require cardiologists with comprehensive knowledge of HR disorders and who are trained in cardiovascular catheter manipulation, heart electrical signal recording and interpretation, and device implantation and follow-up to ensure both patient's safety and quality. Thus, it appears to be imperative to promote and ensure sufficient and homogeneous training and qualification in HR management amongst these professionals in Europe.

In addition, the European Council of Ministers adopted a recommendation on the development and implementation of systems on 30 September 1997 to improve the quality and homogeneity of Health Care Services. The recommendation stated that *quality systems must be publicly controlled through objective external evaluation* by independent organizations. Although training and accreditation programmes are conducted both nationally and regionally, coordination at the European level is needed for two reasons in particular:

1. Transnational cooperation is not well organized resulting in the duplication of work and an inability to compare work implemented in different countries due to unnecessary methodological variations.
2. The development of a uniform and a consistent set of standards will provide a good tool to facilitate qualified health services and ensure free movement across barriers, both for professionals and for patients.

These two reasons are even more relevant nowadays due to the development experienced by the European health care systems, the increasing national integration of the European Union, and the challenges currently arising, such as increased management autonomy, intercountry invoicing, and competition between Health Care centres.

These reasons supported the commitment of the European Society of Cardiology (ESC), through the European Heart Rhythm Association (EHRA), in organizing such a European system together with the Registries of European certified units, professionals, and activities. A European programme in this field will be of utmost interest and will represent a harmonized and uniform way to ensure high standards of excellence. Thus, the general aim is to organize a European Core Curriculum for the HR specialist associated with an Accreditation System to certify professional practice through the following objectives:

1. Definition of the scope of the HR speciality (Syllabus)
2. Development of a minimum standards and objectives recommendation for training in HR management (Core Curriculum)
3. Development of an Accreditation model for European HR professionals and teaching units (Accreditation)
4. Development of a Registry for European HR accredited professionals and teaching units and its activity (Registries)

This document describes the EHRA system.

The ESC, the EBSC, and the EHRA

The European Society of Cardiology (ESC) is a private, non-profit making organization. The goals of the ESC 'to foster the development of cardiology, to further scientific exchanges, to encourage personal contacts, and to establish standards of training for cardiologists and those who work in the field of cardiovascular disease' are clearly defined in the original statutes. The ESC, after 50 years of existence, has now broadened its goals and is 'dedicated to improving the quality of life of the European population by reducing the impact of cardiovascular disease'. The society is comprised of both European and foreign cardiologists and other professionals related to cardiovascular diseases. The Chairman and the Board of Directors are selected biennially. The ESC does not receive public funds and is neither legislative nor authoritative.

The Heart Rhythm Association (EHRA) is a registered branch of the ESC, which specifically deals with aspects related to cardiac electrical physiology and HR problems. Its general aim is to foster the development of specific areas of expertise in HR and to improve collaboration between the common interests of different Working Groups in certain areas. The goals of the EHRA 'to improve the quality of life of the European population by reducing the impact of cardiac arrhythmias and reduce sudden cardiac death' are defined in the statutes. The EHRA maintains the links and cohesion with the entire ESC group, while allowing a more specific and a more fruitful development of its particular area of expertise.

The EHRA is integrated in the EBSC (European Board for the Specialty of Cardiology) Taskforce on Subspecialty Accreditation. The EBSC is a composite of the ESC and the UEMS (Union of the European Medical Specialists), which is linked to the European Commission. The mission of this task force is defining and promoting standards, requirements, and procedures in subspecialty accreditation in cardiology. At present, the following subspecialties under evaluation for recognition by this task force are acute cardiac care, echocardiography, HR management, interventional cardiology, nuclear cardiology, and cardiovascular magnetic resonance.[2]

Definitions and glossary

Accreditation

Accreditation is a process resulting in a diploma/certificate indicating proficiency. This applies to individuals, institutions, and laboratories. Different terms have been often used and confused with accreditation including:

– *Accreditation*: signifies granting credit or recognition, or proving certitude. It is voluntary and motivational, and its objective is the improvement of quality. The standards measured are optimal. It is performed in health centres, which already have the appropriate authorization from the corresponding official organization to carry out a certain activity and, therefore, are already operational.
– *Authorization*: signifies granting permission. It is obligatory and it is always performed prior to opening a specific programme. Its purpose is therefore legislative, that is to say, to verify compliance with the minimum standard criteria demanded before granting authorization to commence a specific activity.

– *Inspection*: signifies examining in detail or verifying. It is obligatory and it is implemented to maintain control. Its purpose is supervisory, that is to say, its objective is to check compliance with the criteria demanded by the regulations once a programme is opened.
– *Homologation*: signifies verifying authoritatively compliance with determined specifications or properties. It can be voluntary or obligatory. The objective is to guarantee that the product complies with previously defined specifications. The purpose is homologous. Minimum standards must be measured. It may or may not be operational.

Certification

Certification is not used in this document. It is not equivalent to accreditation; it involves passing an assessment of knowledge, which is only a part of an accreditation process. Assessments of knowledge demonstrate objective competency in the theory within a field.

Curriculum

A curriculum is a formal education plan for a training programme that intended to establish specific learning outcomes.

Syllabus

A syllabus is a listing of subject matters that are covered in a training programme.

Logbook

A logbook is a record of the trainee's practical experience.

Heart rhythm specialist

A cardiologist with specific knowledge, training, skills, and attitudes for the study, management, research, and teaching of the HR disorders.

Cardiac electrophysiology

Cardiac electrophysiology (EP) is the field of cardiology related to the study and management of HR physiology and disorders. It includes both invasive and non-invasive techniques. Invasive Cardiac EP is the discipline that involves the study, diagnosis, treatment, and prevention of cardiac arrhythmias through recording electrical activity, stimulation, and the controlled creation of endocardic and epicardiac lesions in the heart and its principal vessels through electro-catheters, which are generally introduced by the percutaneous vascular route. Knowledge of the management of HR implantable devices, as one of the diverse diagnostic and therapeutic approaches for HR disorder management, is also required for proficiency in this specialty.

Heart rhythm implantable devices: pacemakers, defibrillators, and others

Heart rhythm implantable devices are devices that are designed for implantation in the human body for the study, diagnosis, prevention, or management of HR disorders. The most frequent HR implantable devices are pacemakers (PMs), implantable cardioverter–defibrillators (ICDs), and devices for cardiac resynchronization therapy (CRT). Proficiency in this discipline requires also a basic knowledge about invasive and non-invasive cardiac EP.

Organizations

EBSC is the European Board for the Speciality of Cardiology.
EBAC is the European Board for Accreditation in Cardiology.
UEMS-CS is the Union Européenne des Médecins Spécialistes-Cardiology Section.

Summarized syllabus

Heart rhythm management is a rapidly developing field with the most extensive and complex knowledge base in cardiology. This has been recognized by some organizations, such as the American Board of Internal Medicine, which considers HR management to be sufficient in itself to constitute a subspecialty, a consideration that, until a short time ago, was not held by any other discipline in cardiology.[3] In addition, the cardiologist, who is a subspecialist in this area, must also understand other techniques and related areas, many of which are necessary to undertake and interpret the procedures, and others without which their ability to take decisions would be limited. The Subspecialty Syllabus is the comprehensive index of the present knowledge in the HR Subspecialty, which includes knowledge in both Invasive Cardiac EP and Cardiac Rhythm Implantable Devices. Development of such a comprehensive knowledge base required by the HR specialist is warranted. However, it must be recognized that such a syllabus should be considered just as a summary because it is unrealistic to detail all the possible aspects and variants related to the HR field reported in the scientific literature. This is especially true since knowledge in this field is developing rapidly and both major and minor advances are regularly published in peer-reviewed scientific journals. Therefore, for formal aspects, the knowledge base of the HR subspecialty will consider all data and information related to it that has been made public and are currently available as published work in international peer-reviewed journals, either in the paper or the electronic format. For a full list of peer-review journals, please refer to the major scientific citation indexes, such as Current Contents© or Medline©. Nevertheless, a summarized syllabus for the HR specialist, in general, and for Invasive Cardiac EP and HR Implantable Devices, in particular, has a practical interest and is presented in this section.

Syllabus for the heart rhythm specialist

1. Normal and abnormal anatomy of the heart and the conduction system
2. Normal and abnormal general physiology and heart EP, including ion channels, cellular EP, autonomous system influences, and the basic mechanisms of rhythm disorders, syncope, and sudden death
3. Arrhythmic disorders (epidemiology, genetics, pathophysiology, clinical features and diagnosis, prognosis and risk evaluation, treatment, prevention, and ESC Guidelines):
   - 3.1 Sinus node and atrial impulse formation and conduction disorders
   - 3.2 AV nodal and His-Purkinje conduction disorders

- 3.3 Atrial and thoracic vein ectopy and tachycardias
- 3.4 Atrial flutter
- 3.5 Atrial fibrillation
- 3.6 Junctional and AV node ectopy and tachycardias
- 3.7 Accessory pathway mediated tachycardias
- 3.8 Ventricular ectopy and tachycardias
- 3.9 Ventricular fibrillation
- 3.10 Autonomic disorders (carotid sinus hypersensitivity, neurocardiogenic syncope, and other)

4. Arrhythmogenic diseases and syndromes (epidemiology, genetics, pathophysiology, clinical features and diagnosis, prognosis and risk evaluation, treatment, prevention, and ESC Guidelines):
   - 4.1 Ischaemic cardiomyopathy
   - 4.2 Non-ischaemic cardiomyopathies:
     - 4.2.1 Idiopathic dilated cardiomyopathies
     - 4.2.2 Hypertrophic cardiomyopathies
     - 4.2.3 Right ventricular arrhythmogenic cardiomyopathies
     - 4.2.4 Neuromuscular cardiomyopathies
     - 4.2.5 Valvular-related cardiomyopathies
     - 4.2.6 Congenital diseases
     - 4.2.7 Other (Chagas disease, etc.)
   - 4.3 Channelopaties and other inherited syndromes:
     - 4.3.1 Long and short QT syndromes
     - 4.3.2 Brugada syndromes
     - 4.3.3 Catecholaminergic polymorphic ventricular tachycardia
     - 4.3.4 Congenital conduction disorders
     - 4.3.5 Other
   - 4.4 Other situations leading to rhythm disorders
5. Diagnostic procedures and techniques in Heart Rhythmology and Clinical EP (rationale, materials and equipment, techniques and procedures, complications, result interpretation, indications and contraindications, and ESC Guidelines):
   - 5.1 Clinical evaluation (history and physical examination)
   - 5.2 Electrocardiography (ECG):
     - 5.2.1 Conventional 12-lead ECG
     - 5.2.2 ECG monitoring (Holter, event monitoring, implantable event, and loop monitoring)
     - 5.2.3 Heart rate variability and baroreflex sensitivity
     - 5.2.4 Signal-averaged ECG
     - 5.2.5 T-wave and micro-T-wave alternants
     - 5.2.6 Body surface mapping
   - 5.3 ECG-pharmacological tests:
     - 5.3.1 Type I drugs for His-Purkinje system challenge
     - 5.3.2 Type I drugs for Brugada ECG unmasking
     - 5.3.3 Adrenaline for congenital long QT syndrome unmasking
     - 5.3.4 Adrenaline/atropine for sinus node dysfunction
     - 5.3.5 Adenosine/ATP for sinus node and AV node dysfunction
     - 5.3.6 Other
   - 5.4 Exercise tests
   - 5.5 General knowledge in imaging techniques [fluoroscopy, echocardiography, magnetic resonance imaging (MRI), computed tomography (CT), nuclear imaging, angiograms, and other]
   - 5.6 Autonomic nervous system evaluation:
     - 5.6.1 Carotid sinus massage
     - 5.6.2 Supine to orthostatism for orthostatic hypotension evaluation
     - 5.6.3 Tilt testing
     - 5.6.4 Other
   - 5.7 Transoesophageal electrical evaluation
   - 5.8 Invasive EP studies
   - 5.9 Other
6. Therapies in heart rhythmology and Clinical EP (rationale, material and equipment, techniques and procedures, side-effects and complications, results, indications and contraindications, and ESC Guidelines):
   - 6.1 Physical and autonomous system manoeuvres
   - 6.2 Resuscitation and life support
   - 6.3 Drugs with antiarrhythmic effects
   - 6.4 Drugs for associated rhythm problems (anticoagulants, vasodilatators, and other)
   - 6.5 Transient electrical stimulation:
     - 6.5.1 Transcutaneous
     - 6.5.2 Transoesophageal
     - 6.5.3 Intracardiac percutaneous
   - 6.6 Cardioversion and defibrillation
   - 6.7 Invasive EP guided therapies
   - 6.8 Percutaneous catheter ablation
   - 6.9 Implantable HR devices (PMs, ICDs, CRTs, and other)
   - 6.10 General knowledge of cardiac and antiarrhythmic surgery
   - 6.11 Other
7. Professional, legal, ethical, and socioeconomical aspects

Specific syllabus for invasive cardiac electrophysiology

This syllabus includes the comprehensive knowledge of the areas included in the summarized syllabus for the HR specialist, but with specific knowledge in invasive cardiac EP, as follows:

1. EP laboratory equipment (fluoroscopy, catheters, sheaths, EP signal recording systems, navigation systems, programmed electrical stimulation systems, and other)
2. Catheter placement techniques including cardiac access (transvenous, pericardial, and other), guiding means (fluoroscopic or non-fluoroscopic, manual or remote navigation, and other), and other
3. ECG and EP signals (bipolar/unipolar, filters, voltage/timing/morphology, and other)
4. Programmed electrical stimulation techniques (pulse width/amplitude, unipolar/bipolar, continuous/extrastimulus stimulation, atrial/ventricular/other location stimulation, pacing algorithms, and other) and pharmacological tests and modulation
5. Angiography of cardiac chambers and vascular structures, such as the pulmonary veins

6. Basic EP principles (intervals, refractoriness, conduction velocity, block/gap, and other)
7. Basic arrhythmia mechanisms (macroreentry, microreentry, automatism, triggered activity, reflection, and other)
8. Impulse formation and conduction within the heart (sinus function, sinoatrial conduction, atrial conduction and refractoriness, AV nodal and His Purkinje physiology, ventricular conduction and refractoriness, and other)
9. ECG and EP (cardiac activation, responses to electrical stimulation and to drug administration, EP diagnosis, and other) of normal HR and electrical impulse conduction
10. ECG and EP (induction, cardiac activation, responses to electrical stimulation and to drug administration, cardiac activation, EP diagnosis, and other) of the different types and variants of sinus and AV node and His-Purkinje impulse formation and conduction defects including sick sinus syndrome, AV block, intraventricular conduction blocks, and autonomous system mediated disorders (carotid sinus hypersensitivity, neurocardiogenic syndromes, and other)
11. ECG and EP (induction, termination, cardiac activation, responses to electrical stimulation and to drug administration, EP diagnosis, and other) of the different types and variants of sinus node and atrial arrhythmias, including atrial ectopy, atrial escape and accelerated rhythms, sinus node and atrial tachycardias, atrial flutters, and atrial fibrillation
12. ECG and EP (induction, termination, cardiac activation, responses to electrical stimulation and to drug administration, EP diagnosis, and other) of the different types and variants of junctional arrhythmias, including junctional ectopy, junctional escape and accelerated rhythms, and junctional tachycardias
13. ECG and EP (induction, termination, cardiac activation, responses to electrical stimulation and to drug administration, EP diagnosis, and other) of the different types and variants of ventricular arrhythmias, including ventricular ectopy, ventricular escape and accelerated rhythms, ventricular tachycardias, ventricular flutter, and ventricular fibrillation
14. ECG and EP (induction, termination, cardiac activation, responses to electrical stimulation and to drug administration, EP diagnosis, and other) of the different types and variants of AV accessory pathways and AV accessory pathways mediated arrhythmias, including ectopy, escape and accelerated rhythms, and tachycardias
15. ECG and EP (induction, termination, cardiac activation, responses to electrical stimulation and to drug administration, EP diagnosis, and other) of the different types and variants of inherited rhythm disorders (long and short QT syndromes, Brugada syndrome, catecholaminergic polymorphic ventricular tachycardia, and other)
16. Ablation techniques (catheters, energies, biophysics, mapping, anatomical substrates, success predictors, and other) of the different rhythm disorders previously stated
17. Complications and adverse effects of EP studies and ablation: pathophysiology, diagnosis, prevention, and management
18. Professional, legal, ethical, and socioeconomical issues

Specific syllabus for heart rhythm implantable devices

This syllabus includes the basic knowledge of the areas included in the summarized syllabus for the HR specialist, but with specific knowledge of HR implantable devices (Cardiac Pacing, ICDs, and other), as follows:

1. Historical perspectives of HR implantable devices
2. Conventional and non-conventional indications of HR implantable devices (bradiarrhytmias, tachycarrhythmias, heart failure and cardiomyopathies, sleep apnoea syndrome, and other)
3. Electricity and electronics related to physic laws, waveforms, parameters, measurements, and units
4. Haemodynamics and physiology of cardiac pacing and defibrillation
5. HR implantable devices and components:
   - 5.1 Models and modes (international codes, other)
   - 5.2 Generators (battery, capacitors, circuits, and other)
   - 5.3 Leads and arrays (material, structure, type, electrodes, coils, connector/adapters, and other)
   - 5.4 Sensors
   - 5.5 Ancillary materials (sheaths, guidewires, and other)
6. Implantation and replacement/extraction techniques (surgery, lead implantation/replacement techniques, and other)
7. Fluoroscopy, angiography, and other navigation techniques
8. Electrogrammes, markers, intervals, Holter features, and other storage and diagnosis capabilities
9. Device testing at implantation (pacing and sensing measurements and parameters, arrhythmia induction and termination, and other)
10. Rhythm and device detection programming:
    - 10.1 Detection zones
    - 10.2 Refractory and blanking periods
    - 10.3 Tachycardia discrimination (single and dual chambers)
    - 10.4 AV synchrony, hysteresis, automatic mode change
    - 10.5 Rhythm and device problem detection alarms
11. Rhythm therapy programming:
    - 11.1 Cardioversion and defibrillation (modes, parameters, algorithms and automatisms, and other)
    - 11.2 Antitachycardia pacing (modes, parameters, algorithms and automatisms, and other)
    - 11.3 Antibradicardia pacing (modes, parameters, algorithms and automatisms, and other)
    - 11.4 Haemodynamic and resynchronization pacing (modes, parameters, algorithms and automatisms, and other)
12. Follow-up:
    - 12.1 Longevity estimation and general and interval recommendations
    - 12.2 Device parameters to measure (sensing, pacing, defibrillation, lead integrity, battery life, arrhythmia episodes, and other)
    - 12.3 Normal and abnormal ECG at follow-up in HR device recipients
    - 12.4 Memory loop/channels markers
    - 12.5 Invasive and non-invasive evaluation of pacing, cardioversion-defibrillation, and cardiac synchronization

Table 1 Anatomy of the heart and the conduction system

Objectives	Knowledge	Skills	Behaviours and attitudes
Become familiar with the anatomy of the heart and the conduction system, especially in relation to the different diagnostic and therapeutic procedures in heart rhythmology	Describe the anatomy of the heart chambers, the pericardium sac, and the main components of the vascular system (major thoracic arteries and veins)	Demonstrate knowledge of the anatomy of the heart by properly performing right and left side catheterization, interatrial transseptal access, device implantation, and ablation procedures	Take responsibility of choosing different vascular accesses or targeting different cardiac chambers by weighting up the risk and benefits for the patient
Become familiar with both the arterial and venous vascular system distributions, especially concerning the aspects aimed at gaining peripheral access	Describe the anatomy of the conduction system and the propagation of the electrical impulse through the heart	Demonstrate knowledge of the conduction system by properly performing electrophysiological studies, ablation procedures, and device implantations	Discuss and accept advice from other specialized physicians, such as cardiac surgeons, pathologists, radiologists, or paediatric physicians in anatomically complex cases
Be able to correlate the anatomy of the heart with images resulting from the main cardiac imaging techniques (echocardiography, cardiovascular magnetic resonance, cardiac computed tomography, other) and EP 3D navigators	Outline the anatomy of the main components of the peripheral venous system commonly used for vascular access during PM/ICD implantation	Demonstrate knowledge of the aorta and coronary artery systems	
	Outline the anatomy of the main components of the peripheral arterial and venous systems commonly used for vascular access during electrophysiological studies and ablation procedures	Demonstrate knowledge of the coronary venous system	
	Outline the anatomy of the coronary venous system, especially in relation to electrocatheter and CRT lead placement	Demonstrate knowledge of the peripheral venous system by correctly gaining peripheral access	
		To be able to select the appropriate vascular access based on the type of procedure and the specific characteristics of the patient	

Table 2 General physiology and heart electrophysiology

Objectives	Knowledge	Skills	Behaviours and attitudes
Have a good understanding of the cardiomyocyte ion channels and the effects of ionic disbalance on cardiac EP	Ion channels function and regulation and cellular EP	Demonstrate knowledge of ion channels function and regulation and cellular EP	Select the appropriate diagnostic procedure or therapy for the patients by weighing up the risk and benefits in relation to heart EP
Have basic understanding of general physiology and a deep understanding of cardiac and major cardiac EP vessels in normal subjects and in patients with cardiac arrhythmias	Basic mechanisms of arrhythmias: normal automatism, abnormal automatism, triggered activity, focal reentry, macroreentry, and other mechanisms	Demonstrate knowledge of general physiology and heart EP	Appreciate the limitations and the potential risks of certain antiarrhythmic drug therapies in relation to their ionic mechanisms
		Demonstrate knowledge of specific mechanisms of arrhythmias, syncope, and sudden death	
Have a good understanding of the effect of the autonomic nervous system on the heart	Normal and abnormal EP of the heart and the major thoracic vessels	Demonstrate knowledge of the autonomic nervous system influences on heart EP and heart arrhythmias	Appreciate the importance of coexisting structural heart diseases in relation to the electrophysiological properties of the heart and the most likely arrhythmia mechanism
	Specific mechanisms of rhythm disorders, syncope, and sudden death		
	Autonomous system influences on heart EP and heart arrhythmias		

12.6 Telemonitoring

13. Pathophysiology, diagnosis, prevention, and management of complication:
    - 13.1 Related to implantation and surgical techniques (pneumothorax, bleeding, thrombosis, infection, and other)
    - 13.2 Related to electrode, arrays, or generator dysfunction (connection, dislocation, isolation defects, conductor defects, and other)
    - 13.3 Related to inappropriate model selection and programming (PM syndrome, arrhythmogenesis, and other)
    - 13.4 Related to malfunction (over or undersensing, pacing, defibrillation, electrical and magnetical interferences, and other)
    - 13.5 Related to drug or other device interactions
    - 13.6 Related to psychological problems
14. Professional, legal, ethical, and socioeconomical issues

General learning objectives

Individual training in HR management requires the basic skills of a good physician. He/she should have a solid background in all aspects of general medicine, which can provide the basis for specialized arrhythmia care. Cardiac arrhythmia management is recognized as a particularly challenging field of expertise. The complexity of arrhythmia mechanisms and the consequent complexity of understanding them and the management options are challenging. This justifies the dedicated training period following general cardiology training.[4] At the same time, individuals in the field require a sound understanding of the research principles and mechanisms, including study design and statistical principles. In addition, a thorough knowledge of the principles of clinical ethics and clinical and research governance is required. Patients with cardiac arrhythmias are a particularly vulnerable group and understanding cardiac arrhythmia abnormality can be a significant challenge for the lay person. Thus, development of patient communication and 'people' skills is highly important. Finally, administration of clinical practices requires a broad set of administrative skills. The individual responsible for service management needs to equip him/herself with an understanding of the basic management principles, including management skills, such as the ability to successfully 'people-manage', write business plans, perform audits, negotiate the purchase of consumables and equipment, and undertake appraisal.

The knowledge that trainees require to become competent in the management of patients with HR disorders is defined in the Core Syllabus section. However, the Core Curriculum needs to establish what the trainee should be able to do at the end of the training period, that is, the general learning objectives. This section presents tables (*Tables 1–12*) of the main learning objectives to achieve in the different areas of HR management together with the knowledge, the practical skills, the behaviour, and the attitudes the trainee should have achieved at the end of the training period.

Training requirements and plan

This section details the minimal requirements of the training programme for HR specialists. Following this training programme,

Table 3 Diagnostic procedures and techniques: general

Objectives	Knowledge	Skills	Behaviours and attitudes
Select and indicate correctly the different non-invasive diagnostic techniques used in heart rhythmology Be able to perform and interprete the different non-invasive diagnostic techniques specifically related to heart rhythmology Be able to integrate the results of the different diagnostic techniques into the individual care of patients with rhythm disorders	Basic knowledge of techniques, modalities, indications, interpretation, and the diagnostic yield of general cardiology non-invasive and imaging techniques such as: Exercise testing X-ray Echocardiography Cardiac magnetic resonance imaging Cardiac-computed tomography imaging Nuclear cardiology Blood sampling and other laboratory analysis Genetic analysis Extensive knowledge of techniques, modalities, indications, interpretation, and the diagnostic yield of non-invasive rhythmology techniques such as: Clinical evaluation (history, physical exam) of patients with rhythm disorders Electrocardiography: – Conventional 12-lead ECG – ECG monitoring (Holter, event monitoring, implantable event, and loop monitoring) – Signal-averaged ECG and body surface mapping – Heart rate variability and baroreflex sensitivity – T-wave and micro-T-wave alternants – ECG-drug infusion tests (flecainide, etc.) – Transoesophageal electrical recording Autonomic nervous system evaluation: – Carotid sinus massage – Tilt testing	Choose the non-invasive technique for specific clinical situations, including a thorough understanding of the Bayesian approach Interpret the results of the general cardiology non-invasive and imaging techniques Implement and interpret the non-invasive rhythmology techniques Transoesophageal recording catheter placement techniques and interpretation of recording findings and stimulation responses Manage the non-invasive rhythmology technique equipment (ECG machines, ECG monitoring systems and recorders, tilt test system, etc.) Evaluate each diagnostic procedure in the clinical context and in reference to other non-invasive or invasive techniques	Choose the diagnostic techniques, modalities, and protocols in a clinically useful and cost-effective way, avoiding over- and under-utilization of tests Recognize and remain up-to-date with developments in the field of non-invasive diagnostic procedures Explain to patients the implications of the results of the various diagnostic tests in an understandable manner Be able to cooperate with echocardiography cardiologists, radiologists, and other non-invasive technique physicians when appropriate

Table 4 **Diagnostic procedures and techniques: invasive cardiac electrophysiology**

Objectives	Knowledge	Skills	Behaviours and attitudes
Be able to indicate, perform, and interpret clinical invasive cardiac EP studies Be able to integrate the results of clinical invasive cardiac EP studies with those from different diagnostic techniques into the individual care of patients with rhythm disorders	EP laboratory equipment (fluoroscopy, catheters, sheaths, EP signal recording systems, navigation systems, programmed electrical stimulation systems, other) ECG and EP signals (bipolar/unipolar, filters, voltage/timing/morphology, other) Programmed electrical stimulation techniques (pulse width/amplitude, unipolar/bipolar, continuous/extrastimulus stimulation, atrial/ventricular/other location stimulation, pacing algorithms, other) and pharmacological tests and modulation ECG and EP (induction, cardiac activation, responses to electrical stimulation and to drug administration, cardiac activation, EP diagnosis, other) of the different types and variants of cardiac arrhythmias, conduction disturbances, arrhythmic clinical syndromes, genetic disorders, and autonomous system mediated disorders Complications and adverse effects of EP studies: patho-physiology, diagnosis, prevention, and management	Catheter placement techniques including cardiac access (transvenous, pericardial, other), guiding means (fluoroscopic and non-fluoroscopic), and other Manage the EP laboratory equipment (fluoroscopy, catheters, sheaths, EP signal recording systems, navigation systems, programmed electrical stimulation systems, other) Interprete recording findings and stimulation responses Recognize and manage the complications and the adverse effects of EP studies	Recognize and improve the anxiety and psychological indispositions of patients before, during, and after the procedure Communicate the procedure results to patients and relatives in an understandable, objective, and serene manner Select the best available therapy according to the procedure results, the accepted clinical evidences, and ESC practice guidelines Recognize and remain up-to-date with developments in the field of invasive cardiac EP

Table 5 Therapies: general

Objectives	Knowledge	Skills	Behaviours and attitudes
Be able to indicate, perform, and evaluate the results of non-invasive and invasive rhythmology therapies other than ablation, such as antiarrhythmic drug administration, transoesophageal pacing, transient endocavitary pacing electrical stimulation, or electrical cardioversion Understand the equipment and technologies, and their operation for these therapeutic techniques	Extensive knowledge of indications, techniques, performance, and response interpretation of therapy modalities in heart rhythmology other than ablation, such as: Oral and intravenous drug administration: – Antiarrhythmic drugs – Non-antiarrhythmic drugs with antiarrhythmic effects – General drugs used in cardiology, such as anticoagulants and inotropic drugs – Sedative drugs Physical and autonomous system manoeuvres Resuscitation and life support Transient electrical stimulation: – Transcutaneous – Transoesophageal – Intracardiac percutaneous Cardioversion and defibrillation Basic knowledge of indications, techniques, performance, and response interpretation of other therapy modalities in heart rhythmology Arrhythmia surgery	Choose the therapeutic technique for specific clinical situations Perform techniques and response interpretation of therapy modalities in heart rhythmology other than ablation Manage the technical equipment (monitoring systems, pacing and defibrillation systems, etc.) Interprete the responses to arrhythmia surgery Evaluate each therapeutic procedure in the clinical context and in reference to other techniques	Educate patients about the treatment options available to them and explain the treatment strategies Recognize and improve the anxiety and psychological indispositions of patients before, during, and after the therapeutic procedure Communicate the procedure results to patients and relatives in an understandable, objective, and serene manner Develop a critical attitude towards the therapeutic techniques and the selection of the best available therapy according to the procedure results, the accepted clinical evidences and ESC practice guidelines Commit to the audit of long-term outcomes, including infection and procedural complications Foster a team approach to the procedures including a close relationship with cardiac technicians and other health care professionals Recognize and remain up-to-date with developments in the field

Table 6 Therapies: catheter ablation

Objectives	Knowledge	Skills	Behaviours and attitudes
Understand the anatomical substrates that govern the approach to catheter ablation of cardiac arrhythmias	Normal and abnormal anatomical formations that govern the approach to intracardiac catheter placement	Patient and procedure-type selection for specific arrhythmia management strategies/targets	Develop a critical attitude towards ablation techniques
Master and understand how to demonstrate/diagnose/confirm any given arrhythmia mechanism and the critical components of its mechanism by a combination of pattern recognition and electrical interaction with the arrhythmia mechanism (e.g. extrastimulation/entrainment)	Intracardiac catheter positioning and electrophysiological pacing techniques that elucidate the arrhythmia mechanism	Performance of both simple and complicated protocols of extrastimulation/pacing/catheter manipulation that generate intracardiac electrogram recordings; the examination of which will identify the arrhythmia mechanism	Develop a correct attitude to an interventional procedure, particularly the appreciation of sterility and antibiotic usage
Understand the equipment and technologies and their operation that facilitate electrophysiological interventions	Electrogram activation patterns and their changes in response to planned electrophysiological perturbations that allow deductive reasoning to determine arrhythmia mechanism	Use of imaging techniques that allow selection of catheters/procedural equipment and a technical approach sufficient for the safe and expeditious diagnosis/treatment of cardiac arrhythmias	Commit to the audit of long-term outcomes, including infection and procedural complications
Master an understanding of catheter placement for arrhythmia mechanism elucidation and ablation	Use of stimulators, catheters, mapping systems, and lesions creation technologies sufficient for their safe application in patient treatment	Practical competency in catheter deployment/manipulation and interaction with stimulators/mapping technologies/lesion creating technologies (e.g. radiofrequency generator)	Foster a team approach to diagnostic/interventional catheter ablation procedures including a close relationship with cardiac technicians
	Use of 3D non-fluoroscopic navigation system (Carto, Ensite, etc.)	Practical competency in use of mapping technologies/lesion creating technologies (e.g. radiofrequency generator) sufficient to allow accurate mapping/characterization of the arrhythmia mechanism and, when appropriate, safe lesion creation for the purpose of ablation	Work closely with other health care professionals as necessary: cardiac technicians, cardiologists, infection control, care of the elderly, neurologists, etc.
	Basic knowledge about remote navigation		Educate patients about the treatment options available to them and explain the treatment strategies
	Angiography performance (e.g. pulmonary veins)		Appreciate the psychological impact of the patient's arrhythmia illness on the patient and his/her family, and manage it sensitively

Table 7 Therapies: implantable devices: pacemakers

Objectives	Knowledge	Skills	Behaviours and attitudes
Have a good understanding of the fundamentals of cardiac stimulation both electrically and the engineering involved	The principles of pacing, the engineering of PM and of pacing leads	Select the appropriate patient for implantation	Correct attitude to a surgical approach, particularly with respect to sterility and antibiotic usage
Have detailed knowledge of pacing device and PM lead characteristics	The cardiac conduction system and its disease processes	Perform safe implantation of single and dual chamber PMs via the cephalic, subclavian, or internal jugular approaches	Foster a team approach to pacing including a close relationship with cardiac technicians
Have detailed knowledge of the published guidelines for implantation of PM and clinical indications	The influence of drugs on bradiarrhytmias	Perform safe intravascular catheter manipulation	Commit to the audit of long-term outcomes including infection and lead complications
Have detailed knowledge of the haemodynamics of cardiac pacing, and the device and mode selection	Cardiac and thoracic anatomy, especially with respect to venous access, including the cephalic, subclavian, and internal jugular vein approach	Develop surgical skills in opening, manipulating, and closing wounds	Develop a critical attitude towards a safe pacing programme in the hospital and to support patients in their community with adequate pacing follow-up
Understand the implantation technique, and the cardiac and thoracic anatomy	The indications and international and national guidelines for correct PM prescription, including pacing mode	Proper insertion and care of temporary pacing wires	Educate patients about the treatment options available to them and explain the treatment strategies
Master safe sterile techniques for all procedures	The safe implantation of PMs including the operating environment and antibiotic usage	Manage peri-procedural complications, e.g. cardiac tamponade, and pneumothorax	Work closely with other health care professionals as necessary: cardiac technicians, cardiologists, infection control, care of the elderly, neurologists, etc.
Have detailed knowledge of the programming of modern PM following implantation including troubleshooting	Management of complications of PM implantation including pneumo-haemothorax and lead perforation	Competent programming of PMs including the programming of sensors	Appreciate the psychological impact of the patient's arrhythmia illness on the patient and his/her family, and manage it sensitively
Have detailed knowledge of the PM malfunction including interference, and PM-mediated tachycardia	Management of lead problems and programming issues specifically related to leads	Competent programming of newer algorithms for atrial tachycardia prevention and termination, and for minimizing ventricular pacing	
Have detailed knowledge of the regulatory and legal aspects	Modern pacing systems and troubleshooting	Manage of PM malfunction and troubleshooting	
	Rate-modulated pacing and sensor technology		
	Medico-legal issues concerning consent, provision of information, and driving restrictions		

Table 8 Therapies: implantable devices (implantable cardioverter-defibrillators)

Objectives	Knowledge	Skills	Behaviours and attitudes
Have a good understanding of the fundamentals of cardiac defibrillation, both electrically and the engineering involved	The principles of defibrillation and the engineering of device and of defibrillating leads of the medical treatment of tachyarrhythmias including interaction of drugs with defibrillation and arrhythmia cycle-length	Select the correct patient for implantation	Appreciate the importance of informed consent and the need to explain lifestyle issues and driving restrictions to the patient
Have detailed knowledge of defibrillating device and lead characteristics	The pro-arrhythmic effect of antiarrhythmic drugs particularly with regards to their effect on left ventricular function	Carefully investigate patients prior to implantation (including whether or not revascularization is required)	Correct attitude to a surgical approach particularly with regards to sterility and antibiotic usage
Have detailed knowledge of the published guidelines for clinical indications of ICDs	Cardiac and thoracic anatomy, especially in respect of venous access including the cephalic, subclavian, and internal jugular vein approach	Explain the procedure, the possible complications, and the possible effects on the patient's lifestyle to the patient and to his/her relatives	Appreciate the importance of team-working with nursing, technical, radiographic, anaesthetic, and, if appropriate, industrial staff
Understand the implantation technique and the cardiac and thoracic anatomy, and master safe sterile technique for all procedures	The indications and international and national guidelines for correct ICD implantation	Assess the anaesthetic/sedation needs of the patient before and during the implant procedure	Appropriate self-confidence and recognition of limitations
Have detailed knowledge of the programming of ICDs following implantation: providing zone of ventricular tachycardia at various rate, discriminators between ventricular and supraventricular tachycardia, appropriate use of ATP and shock therapy, and minimizing ventricular pacing	Management of complications of ICD implantation including pneumo-haemothorax and lead perforation	Assess whether a single, dual, or triple chamber (i.e. biventricular) device is best suited to the patient	Commit to the audit of long-term outcomes including infection and lead complications
Have detailed knowledge of troubleshooting including the recognition of drug-device interaction, and appropriate and inappropriate shocks	Management of lead problems	Perform the implant procedure competently with an acceptably low complication rate	Develop a critical attitude towards a safe preventive programme in the hospital and to support patients in their community with adequate ICD follow-up
Have detailed knowledge of ICD malfunctions and device and leads complication	Management of complications during long-term follow-up	Perform appropriate tests of pacing, sensing, and defibrillation safely and thoroughly during the implant	Educate patients about the treatment options available to them and explain the treatment strategies
Have detailed knowledge of the regulatory and legal aspects	Medico-legal issues concerning consent, provision of information, and driving restrictions	Competent programming of the device in the pre-discharge phase	Work closely with other health care professionals as necessary: cardiac technicians, cardiologists, care of the elderly, neurologists, etc.
		Perform routine follow-up of ICD patients	Appreciate the anxiety that patients suffer with an ICD
		Manage ICD malfunctions and troubleshooting	Appreciate the psychological impact of the patient's arrhythmia illness on the patient and this/her family, and manage it sensitively

Table 9 Therapies: implantable devices (multisite ventricular pacing for resynchronization)

Objectives	Knowledge	Skills	Behaviours and attitudes
Evaluate the proper medical therapy in patients with heart failure	Pathophysiology complications, diagnosis, prevention, and management	Be able to select appropriate patients for CRT	Take a sensible, professional attitude to CRT, learn under supervision with appropriate requests for advice
Appreciate the adjunctive role of CRT in the management of patients with heart failure	Historical of techniques available to identify patients likely to benefit from CRT and to be aware of limitations of these techniques	Be able to consent a patient in a balanced and informed way about the success rate, the risks, and the benefits of CRT	Consent patients sensitively with an objective assessment of likelihood of benefit
Have a detailed knowledge of the anatomy of the coronary venous system	Be able to determine when an ICD back-up is required	Be able to proceed with a CRT implant in a safe and logical manner	Appreciate the importance of team-working with nursing, technical, radiographic, anaesthetic, and, if appropriate, industrial staff
Undertake implantation of CRT devices with a high probability of success	Anatomy of the coronary venous system	Be able to recognize the nature of implant difficulties and to take the appropriate action to overcome these	Work closely with other health care professionals as necessary being aware of the importance of a multi-disciplinary team in heart failure management and in maximizing benefit of CRT: cardiac technicians, cardiologists, infection control, care of the elderly, internal medicine specialists, etc.
Recognize and deal with implant or device behaviour complications	All the equipment available, including that for implantation and also for subsequent programming	Appreciate when an alternative technique or approach may be required (e.g. surgical device implantation)	Deal appropriately with patients in whom CRT implantation has not been effective
Be able to optimize therapy delivery including proper programming of stimulation	Relative benefits of different leads and devices	Be able to programme the devices appropriately, and to advise on optimization using recognized techniques such as echocardiography	Appreciate the psychological impact of the patient's illness on the patient and his/her family, and manage it sensitively
Be able to analyse and properly use the diagnostic data coming from the implanted device	Implantation techniques and how to deal with common problems	Be able to analyse and properly use the diagnostic data coming from the implanted device	
	Potential complications		
	Potential of the diagnostic data stored in the device's memory		
	Medico-legal issues concerning consent and provision of information		

Table 10 Arrhythmic disorders

Objectives	Knowledge	Skills	Behaviours and attitudes
Be familiar with the different arrhythmia mechanisms and disorders and the clinical scenarios in which they usually appear Be able to suspect and to establish the arrhythmia mechanism with the ECG and the other diagnostic techniques detailed above, respectively Be able to select the most appropriated treatment for each specific arrhythmia mechanism	Arrhythmia mechanisms and disorders: – Sinus node and atrial impulse formation and conduction disorders – AV nodal and His-Purkinje conduction disorders – Atrial and thoracic vein ectopy and tachycardias – Atrial flutter – Atrial fibrillation – Junctional and AV node ectopy and tachycardias – Accessory pathway mediated tachycardias – Ventricular ectopy and tachycardias – Autonomic disorders (carotid sinus hypersensitivity, neurocardiogenic syncope, other) Arrhythmia epidemiology and prognosis Arrhythmia diagnosis management Arrhythmia therapy management ESC guidelines	Choose the appropriate diagnosis techniques and manoeuvres, including a thorough understanding of Bayesian approach Select, perform, and interpret the different diagnostic and therapeutic techniques Evaluate the arrhythmia disorder in the clinical context and in reference to other disorders	Appreciate the psychological impact of the patient's arrhythmia on the patient and his/her family, and manage it sensitively Select the best available therapy according to the procedure results, the accepted clinical evidences, and ESC practice guidelines Recognize and remain current with developments in the field of the arrhythmia mechanisms

Table 11 Arrhythmogenic diseases and syndromes

Objectives	Knowledge	Skills	Behaviours and attitudes
Be familiar with the different arrhythmogenic diseases/syndromes and the clinical scenarios in which they usually appear	Arrhythmogenic diseases and syndromes: – Ischaemic cardiomyopathy – Non-ischaemic cardiomyopathies: – Idiopathic dilated cardiomyopathies – Hypertrophyc cardiomyopathies – RV arrhythomogenic cardiomyopathies – Neuromuscular cardiomyopathies – Valvular related cardiomyopathies – Congenital diseases – Other (Chagas, etc.) – Channalopaties and other genetic syndromes – Long and short QT syndromes – Brugada syndromes – Ryanodine syndromes – Other situations leading to rhythm disorders	Choose the appropriate diagnosis techniques and manoeuvres, including a thorough understanding of Bayesian approach	Appreciate the psychological impact of the patient's arrhythmogenic disease/syndrome on the patient and his/her family and manage it sensitively
Be able to suspect and to establish the disease/syndrome with the clinical evaluation and the other diagnostic techniques detailed above, respectively		Choose, perform, and interpret the different diagnostic, therapeutic, and preventive techniques	Select the best available therapy or prevention according to the procedure results, the accepted clinical evidences, and ESC practice guidelines
Be able to select the most appropriated treatment or prevention for each specific arrhythmia in the context of the arrhythmogenic disease/syndrome		Evaluate arrhythmia disease/syndrome in reference to other disorders	Recognize and remain current with developments in the field of arrhythmogenic diseases and syndromes
	Arrhythmia epidemiology, prognosis, and risk evaluation		
	Arrhythmia diagnosis management		
	Arrhythmia therapy management		
	ESC guidelines		

Table 12 **Professional, legal, and socioeconomical aspects**

Objectives	Knowledge	Skills	Behaviours and attitudes
Be competent in providing education	Knowledge of the basic methodology for knowledge transmission in lectures and written articles	Be able to prepare lectures and computer presentations	Recognize continual medical education as a pivotal activity in professional practice and maintain a positive attitude towards it
Be competent in reading scientific literature and designing basic medical research	Knowledge of research design, scientific methodology, statistics, and scientific communication (oral and written)	Be able to discuss the methodology of a scientific paper and to develop a basic medical research	Recognize research as a pivotal activity in professional practice and maintain a positive attitude towards it
Understand the medico-legal issues concerning care provision, consent, and information for patients and their families	Knowledge of the National and European Union laws and directives and when applicable, of the provision of health care and information	Be able to understand and apply the legal dispositions	Fully commit to complying with the National and European legislation
Be familiar with the cost and cost-effectiveness analysis of the care provision to patients with rhythm disorders	Notions of the effectiveness and cost of the drugs, materials, and technology used for care provision	Be able to understand and apply strategies of cost-effectiveness	Positive attitude to understanding and applying cost-effective strategies
Be familiar with most companies and products available in the market to manage patients with HR disorders	Knowledge about the products available in the market to manage patients with HR disorders	Be able to keep up-to-date with guidelines	Positive attitude to implementing guidelines in clinical practice
Be familiar with the main professional organizations and scientific societies in the field of HR management	Knowledge of the guidelines of clinical practice issued by the ESC and EHRA	Be able to understand and apply the basic concepts of ethics in professional practice	Recognize and remain up-to-date with new legislations, products, and guidelines, and try to practice according to the state-of-the-art
Be familiar with the guidelines of clinical practice issued by the main scientific societies in the field of HR management	Knowledge of the basic concepts of ethics in professional practice		Positive attitude for a constant ethical behaviour
Establish solid concepts of ethics in professional practice			

the trainee will entitle recognition of theoretical and practical competency in invasive EP and HR management device implantations and follow-up. At the end of the training programme, the trainee should be able to treat independently patients with HR disorders. The duration of training, the training plan, and the certification process are described in this section.

Training duration

Due to the complexity of treating patients with HR disorders and the difficulty of performing catheter ablation procedures and device implantations independently as the first operator, the duration of the training period should be for a minimum of 2 years. During this period, the trainee must be involved in all aspects of HR management, including the research and educational activities of the teaching department. The trainee should not only fulfil the criteria concerning the procedure numbers, but should also undergo a final evaluation. Such an evaluation has been developed by the EHRA, which presently requires the trainee to take and pass the EHRA accreditation exams (invasive EP and cardiac pacing and ICDs) in order register as a HR specialist in this association. Finally, the programme director should provide a written statement concerning the ability of the trainee to treat patients with cardiac arrhythmias at the end of the training period. Assessment of competency should be closely monitored by the programme director and the teachers in order to evaluate the progress of the trainee during the training period.

Trainee requirements

The minimum education, training, experience, and skills necessary to perform HR procedures are designed for trained or trainee cardiologists. A cardiology background is necessary not only to master the technical aspects, but also to verify the indications and contraindications, to conduct investigations, and to give an accurate and comprehensive interpretation of the clinical data. Therefore, the trainee should be a registered cardiologist or should fulfil the requirements of a general cardiologist set in the core curriculum of the ESC in order to enter the programme accordingly. However, because official recognition as a cardiology specialist is delayed several years after the end of cardiology training in some European countries, trainees who finalize their training programme in HR management and who will become a registered cardiologist in less than 5 years after that date will be recognized as registered HR specialists by the EHRA.

Training plan

The trainee should follow a structured teaching programme and the learning objectives detailed in the previous section. The teaching program should include the development of appropriate behaviours and attitudes together with the knowledge and manual skills of the catheter, recording techniques, and the different systems used in the treatment of patients with HR problems. The programme must be comprehensive and completion of the training in one centre is recommended. However, if a centre is not able to develop a complete teaching programme, it should work with other centres to complete its lacking activities or to allow the trainee to participate in teaching programmes developed by EHRA or other recognized educational activities. Therefore, more than one centre may be responsible for the teaching programme although each centre is encouraged to develop a structured teaching programme dealing with the management of HR problems. In addition, simulator training should be encouraged prior to entering the programme in order to shorten the learning curve for procedures such as coronary sinus lead placement.

The training plan should include clinical activities and practical training together with theoretical educational activities, and research activities and education. During the training period, trainees should attend and participate in weekly meetings reviewing topics and discussing patients, indications, results, and procedural-related complications. In addition, the trainee should attend at least one official international subspecialty meeting of a scientific society in the field. The trainee must be involved in research activities in the HR field and should present at least one scientific abstract at a national or international meeting in the field during the training period.

During the 2 year training period, the trainee should participate in the HR training programme for at least 80% of the working hours (based on full-time employment). Although in some cases, it may be possible to expand the training period if the participation drops below 80%, this should remain an exception. During the training period, dedication to the different clinical activities should be distributed as follows:

1. Outpatient clinic: 10% of the training period
2. Device (ICD, CRT, and PMs) follow-up: 10% of the training period
3. Device (ICD, CRT, and PMs) implantations: 10% of the training period
4. Invasive EP: 40% of the training period.

Based on a 2 year training period (assuming that basic cardiology training is completed), training should be distributed as follows:

Months 1–4

Outpatient clinic

During this period, the trainee will treat patients at the outpatient clinic under close supervision of one of the trainers. It should be a dedicated outpatient clinic dealing mainly with patients with arrhythmias. The indication to refer a patient for catheter ablation or device implantation should be discussed with the trainer.

Device follow-up

During this period, the trainee will learn to perform the technical follow-up of device patients.

Furthermore, the trainee must become familiar with the different devices in the HR department.

Arrhythmia clinic

During this period, the trainee will be responsible for the arrhythmia clinic under close supervision of one of the trainers. Special attention should be paid to the development of the HR clinician. Furthermore, the trainee should become familiar with the psychological effects that an ablation procedure or device implant can have on the patient and the patient's relatives.

Interventions/diagnostic procedures
During this period, the trainee should perform arterial and venous access according to the Seldinger technique.

Furthermore, the trainee should be trained to situate diagnostic catheters in the different chambers of the heart. The trainee should become familiar with the EP equipment and the different monitoring systems used during these procedures.

Device implantations
The trainee should perform regular PM implants and assist during the implantation of ICD/CRT devices.

Emergency department and in-hospital emergency
During this period, the trainee should participate in the management of patients with urgent HR disorders under close supervision.

Months 5–8
Outpatient clinic
During this period, the trainee will treat patients at the outpatient clinic under close supervision of one of the trainers. In addition, the trainee should be trained in non-invasive EP (like Holter monitoring, ECG recording, and neuro-humoral testing).

Device follow-up
During this period, the trainee will learn to perform the technical follow-up of device patients.

In addition, the trainee must become familiar with the different devices in the HR department. The trainee should be able to perform routine technical follow-ups independently. The trainee should learn to troubleshoot device-related problems under close supervision.

Arrhythmia clinic
During this period, the trainee will be responsible for the arrhythmia clinic under the supervision of one of the trainers.

Interventions/diagnostic procedures
During this period, the trainee must be able to perform simple diagnostic procedures.

Device implantations
During this period, the trainee should perform regular PM implants and assist during implantation of ICDs and CRT devices.

Emergency department and in-hospital emergency
During this period, the trainee may participate in the emergency department/in-hospital emergency duty service under supervision.

Months 9–12
Outpatient clinic
During this period, the trainee will treat patients at the outpatient clinic independently, but should discuss all patients with one of the supervisors. Furthermore, the trainee should be able to analyse Holter recordings and ECGs independently.

Device follow-up
During this period, the trainee should perform the technical follow-up of device patients.

In addition, the trainee should be able to trouble shoot device-related problems.

Arrhythmia clinic
During this period, the trainee will be responsible for the arrhythmia clinic under supervision of one of the trainers.

Interventions/diagnostic procedures
During this period, the trainee should perform diagnostic procedures and assist during ablation procedures. Furthermore, the trainee should be able to perform a periocardiocentesis in case of an emergency after training.

Device implantations
During this period, the trainee should perform regular PM implants independently and act as operator during ICD implantations under supervision. He/she will assist during CRT implantation.

Emergency department and in-hospital emergency
During this period, the trainee will participate in the emergency department/in-hospital emergency duty service under close supervision.

Months 13–16
Outpatient clinic
During this period, the trainee will treat patients at the outpatient clinic independently and should be able to decide if patients should be referred for catheter ablation or device implantation.

Device follow-up
During this period, the trainee will supervise the follow-up programme. Furthermore, the trainee should be able to solve most device-related problems independently.

Arrhythmia clinic
During this period, the trainee will supervise the arrhythmia clinic (under the supervision of the programme director).

Interventions/diagnostic procedures
During this period, the trainee must perform ablation procedures as the first operator and assist during complex procedures, such as ventricular tachycardia ablation, atrial fibrillation ablation, and atypical atrial flutter ablation. Furthermore, the trainee should be able to perform most diagnostic procedures independently. The trainee should become familiar with transseptal punctures.

Device implantations
During this period, the trainee should perform regular PM and ICD implants and become the first operator in CRTs implantations.

Emergency department and in-hospital emergency
During this period, the trainee will participate in the emergency department/in-hospital emergency duty service under supervision of the programme director.

Months 17–20

During this period, the trainee should be trained to perform complex ablation procedures. Furthermore, the trainee should be able to perform transseptal punctures as the first operator.

Months 21–24

Outpatient clinic

During this period, the trainee must be able to supervise the outpatient clinic (under the supervision of the programme director).

Device follow-up

During this period, the trainee must be able to supervise the device outpatient clinic.

Arrhythmia clinic

During this period, the trainee will be responsible for the arrhythmia clinic.

Interventions/diagnostic procedures

During this period, the trainee should be able to perform all ablation procedures as first operator.

Device implantations

During this period, the trainee will perform regular PM implants and ICD and CRT-D/PM implantations.

Emergency department and in-hospital emergency

During this period, the trainee will participate independently in the emergency department/in-hospital emergency duty service.

Indicative number of procedures

The numbers of procedures performed have been used for a long time as a measure of training. While recognizing the crude nature of the number of procedures as an assessment method, the use of the indicative number of procedures is a useful means of ensuring sufficient exposure to a technique. This section details the minimum number of procedures recommended to be performed by the trainee during the training period. In addition, the levels of competence expected for a given area of a subject matter are provided with the same definitions used in the ESC Core Curriculum for the General Cardiologist,[4] are complementary to them, and are defined as follows:

- *Level I*: experience of selecting the appropriate diagnostic modality and interpreting the results or choosing an appropriate treatment for which the patient should be referred. This level of competence does not include performing a technique.
- *Level II*: practical experience, but not as an independent operator, including assisting in or performing a particular technique or procedure under the guidance of a superior.
- *Level III*: is able to independently perform the technique or procedure unaided.

Table 13 Minimum recommended procedural numbers and levels of competence in non-invasive techniques to be achieved by the HR specialist during training

Technique	Number	Level of competence	Comments
Holter ECG monitoring (external)	50	III	–
ECG event recording	5	III	–
Pharmacological test, autonomic system manoeuvres, and tilt test	25	III	–
Pacemaker follow-up/programming	250	III	–
ICD follow-up/programming	100	III	–
CRT follow-up/programming	50	III	–

Table 14 Minimum recommended procedural numbers and levels of competence in invasive techniques to be achieved by the HR specialist during training

Technique	Number	Level of competence	Comments
Diagnostic invasive electrophysiological studies (as a standalone procedure or prior to an ablation procedure)	200	III	50 as the primary operator
Percutaneous catheter ablation	150	III	35 as the primary operator
Transseptal catheterization	10	III	5 as the primary operator
Pacemaker implantation	50	III	30 as the primary operator
ICD implantation	30	III	15 as the primary operator
CRT implantation	20	III	10 as the primary operator

The trainee should review at least 1000 12-lead ECGs during the training period in addition to the >1000 that he or she should have had reviewed during the cardiology specialty training. In addition, the trainee should gain basic knowledge (level of competence I) in ECG-based techniques, including T-wave alternant analysis, body-surface potential mapping, and heart rate variability. The trainee should also be familiar (level of competence I) with surgery for HR disorders. The recommended procedural numbers and the levels of competence for the rest of the HR procedures are presented in *Tables 13 and 14*.

Training centre and trainer requirements

Training centre requirements

Formal training in HR management must be carried out in a centre that is recognized and accredited by an official organization, such as the EHRA, as a HR Subspecialty training centre. The training centre should be integrated within a full-service cardiology department, which includes an interventional unit, a cardiac imaging department, a heart-failure unit, and a cardio-surgical unit. The institution must be a training centre for general cardiologists and a recognized centre (by the health authorities or according to national laws) for performing all arrhythmia and device-related procedures with the only exception of arrhythmia surgery. Specific arrhythmia surgery programmes have decreased during the last two decades and nowadays few centres perform surgery for ventricular tachycardia or other forms of supraventricular tachycardia other than atrial fibrillation. Therefore, it is acceptable to admit a centre's training programme that collaborates with other centres performing arrhythmia surgery. The centre must have access to at least one dedicated and fully equipped EP catheterization laboratory, it must record procedural related data, and it and must have a complication registration system.

The training centre must employ at least two fully trained, advisable HR specialists, who should be recognized (accredited) by the EHRA. Both of them must be actively involved in the field of HR management for at least 70% of the time (based on a full-time employment). The programme supervisor should be a fully trained HR specialist recognized by the EHRA and who has at least 5 years of experience in the field. In addition, the training programme staff should be active in clinical research related to the field of HR management.

Clinical practice activities: procedures and numbers

The training centre should perform PM, ICD, and CRT device implantation and replacement, invasive electrophysiological procedures, and the following catheter ablation procedures on a regular basis:

- Accessory pathway mediated tachycardias
- AV nodal re-entrant tachycardia/junctional tachycardia
- Ectopic atrial tachycardia
- Atrial flutter from the right and the left atrium
- Atrial fibrillation
- AV conduction ablation
- Ventricular tachycardia: idiopathic and in patients with structural heart disease

The training centre should perform yearly at least 250 invasive electrophysiological diagnostic procedures, 200 catheter ablation procedures, 200 PM implantations/replacements, 50 ICDs implantations/replacements, and 20 CRTs implantations/replacements.

Educational activities

The training centre should organize regular theoretical educational activities on a weekly basis, such as meetings reviewing topics and discussing patients, indications, results, and procedural related complications. In addition, the training centre must encourage the trainee's attendance at official international subspecialty meetings.

Research activities

A training centre should maintain a minimum level of scientific activity and interest in heart rhythmology, which is endorsed by the presentation of at least three related scientific communications at an EHRA recognized official subspecialty congress (Europace, European Society of Cardiology congress, American Heart Association scientific sessions, American College of Cardiology scientific sessions, HR Society congress, and European national societies annual congresses) during the previous 3 years and the publication of at least one scientific article related to heart rhythmology in a journal with an objective 'impact factor' during the previous 3 years.

Infrastructure and equipment

The training centre should be equipped with the state-of-the-art equipment in order to offer current technology treatment approaches. The centre should have the following available on-site:

- Up-to-date monitoring equipment.
- Modern catheterization laboratories: as x-ray exposure is a serious issue in invasive EP and device implantation procedures, X-ray systems allowing dose-reduction and image optimization should be used. Furthermore, X-ray exposure should be As Low As Reasonably Achievable (ALARA principle). X-ray exposure (in mSv or Gy) should be recorded during each procedure. Personal protection should be available. Only trained personnel (according to national laws) should be allowed to operate X-ray equipment.
- Due to the risk of haemodynamic problems and the risk of ventricular arrhythmias, each catheterization laboratory should be equipped with resuscitation equipment and the possibility to sedate and monitor patients. Preferably, it should be possible to deliver deep anaesthesia.
- It should be possible to perform an emergency periocardiocentesis. Operators should have experience of this procedure.
- A multichannel recording system (at least a 16-channel recording system) and a multi-programmable stimulator should be available to perform diagnostic and catheter ablation procedures.
- 3D electro-anatomical mapping is a prerequisite to perform complex ablation procedures (such as ablation of atrial fibrillation or ventricular tachycardia) and it should be available.

- Equipment to evaluate PM and ICD leads during implantation should be available.
- The catheterization laboratory should fulfil criteria to allow implantation of devices. If devices are implanted in an operating theatre, X-ray equipment should meet the same standards as for the catheterization laboratory.
- Patient database: a patient database containing procedural data, complications, and outcome (up to 1 year follow-up) should be available and easily accessible. CRT/ICD centres should have a database containing all technical data about implanted devices and leads. Furthermore, this database should be used to follow device patients.
- MRI scanner: in order to screen and diagnose patients with complex arrhythmias, such as patients with arrhythmogenic right ventricular cardiomyopathy, an MRI scanner should be available.
- Multislice-CT scanner: it is advisable that centres have access to a multislice-CT scanner to allow evaluation of coronary pathology and to reconstruct 3D anatomy.
- Nuclear imaging techniques: nuclear imaging techniques should be used to evaluate patients with ventricular arrhythmias. Nuclear imaging may serve as a 'gate keeper' during the analysis of patients with ventricular arrhythmias.
- A fully integrated and structured heart failure treatment programme should be operational. At least one heart failure specialist should be involved in the decision-making process before the actual CRT implant is carried out. Preferably, the centre has a heart failure outpatient clinic.

Certifying as a training centre

Training centres should comply with the National Quality insurance programme. The National Working Group on Arrhythmias should endorse the training centre and trainers.

Training assessment

Assessment of the trainee and the training programmes is essential, both to guarantee a minimum level of knowledge and practical competence of the trainee and to promote continuous improvement of the training programmes. The assessment methods should include reports by the training programme supervisor and the national society HR organizations, a logbook of procedures, written examinations, and assessment of professionalism. In addition, the assessment process should include an appeal procedure, as an additional quality control of the system provided by their participants, and a revocation procedure for accredited professionals or centres that act incompetently or in an unsatisfactory manner. This assessment process should aim to develop a certification or accreditation system (see glossary) for HR specialists, not to delimit the legal capacity of professional training in this field of cardiology, but for objective certification of the qualification of training personnel and training centres, with the guarantee of required quality from a strictly professional and technical point of view. The implantation of such an accreditation system could play an important role as an informative element when taking decisions in the case of health authorities as well as service professionals and users. The availability of an independent and objective standard would facilitate the consensus of health professionals and the standardizing activities of the National Health Authorities, combined with the European Health Directives.

The EHRA has undertaken the task of assessment and accreditation of centres and professionals by verifying the candidates' credentials, log books and merits, evaluating and verifying the centre and the candidates' professional competence, and implementing and holding accreditation examinations. The centres and candidates who pass the assessment process successfully are entitled with a diploma/certificate indicating training excellence and proficiency, respectively, which will be endorsed and accredited by the EHRA (see *Figures 1* and *2*). The first EHRA's Accreditation exams for Invasive Electrophysiology and for Implantable devices were held in 2005 and the first EHRA's Accreditation titles were issued in 2006.[5]

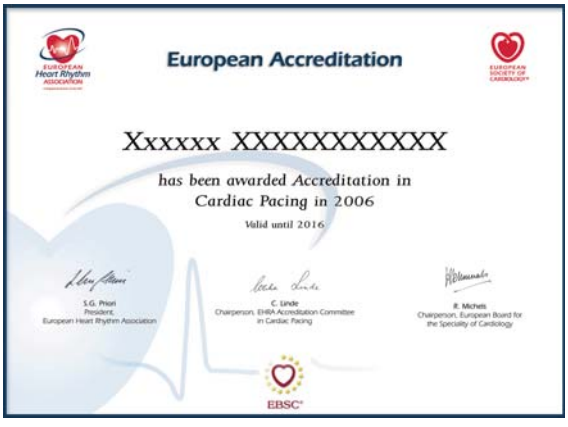

Figure 1 Accreditation certification title issued by EHRA for professionals who are trained in implantable cardiac rhythm devices and who have passed a theoretical examination.

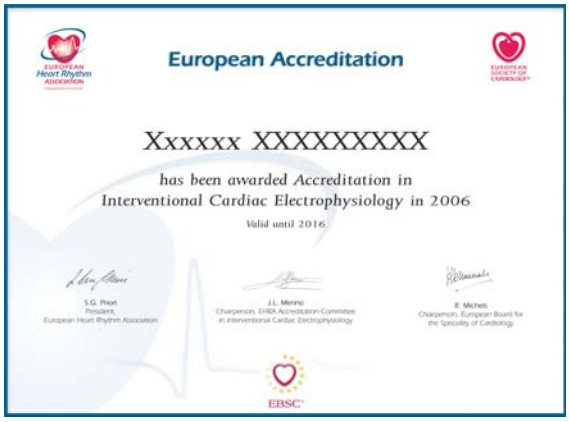

Figure 2 Accreditation certification title issued by the EHRA for professionals trained in implantable cardiac rhythm devices and who have passed a theoretical examination.

Trainee assessment

Reports

A written report signed and stamped by the Training Programme Director, as well as the Head of Service and/or Manager of the corresponding centre certifying that the applicant has completed full-time training of at least 2 years in the said laboratory. This report should detail the activities undertaken, and the degree of competence and autonomy attained by the trainee, and allow verification that all the modalities of HR investigation and management modalities have been performed. This report should not be limited to clinical techniques, but it should also include course attendance, teaching, and research activities. In addition, a letter from the national society HR organizations will support the existence and quality of the training centre and programme supervisor and the lack of knowledge about inappropriate or unethical conduct of the trainee or the training supervisor. A normalized form for these reports should be used for convenience.

Procedural logbooks

The trainees should provide a continuous record (logbook) report detailing their cardiac electrophysiological and HR implantable device training and experience, which must include the required clinical procedures as the first and secondary operator during the training. The log book should contain a summary with the number of procedures performed, the level of competence achieved, and a list of the main procedures with the following data:

1. Centre where the procedure was performed
2. Date of the procedure
3. Patient's birth date and sex
4. The patient's clinical history or register numbers (where the former is unavailable and if permitted by the national data protection law)
5. Diagnosis
6. Type of procedure (diagnostic study, ablation, PM, ICD, and CRT)
7. Result of the procedure (success or failure)
8. Type of complications, if applicable.

This log book will have an electronic format to facilitate data input and importation from other computer applications. A database will be available and will be used to ease the process of information and requirement submission (internet-based). A printed copy of the log book must be dated, signed, and stamped by the Head of Service and/or Manager of the corresponding centre. The candidates for accreditation by this method must attach a standard signed letter of authorization agreeing to facilitate and cooperate with an eventual audit of the procedures reported. The EHRA reserves the right to make formal complaints or accusations within a legal or professional ethics framework as considered necessary in the case of data falsification.

Theoretical examinations

Knowledge will also be assessed by a single theoretical examination on all aspects of HR management. This examination may be divided into two separate examinations, invasive cardiac EP and implantable devices, if it is considered convenient in terms of exam duration or candidate participation promotion due to particular national idiosyncrasies or other reasons. Minor aspects of the examinations

Table 15 Average difficulty scale for questions used in a HR subspecialty accreditation examination

Grade	1 Very easy	2 Easy	3 Average	4 Difficult	5 Very difficult
BC[a]	≥90%	≥70%	~60%	<50%	<30%
Time[b]	<0.5	<1	<2	<3	<4
Knowledge requirements	Requires basic knowledge in the field (is also common to the majority of general cardiologists without special expertise in the field)	Requires more than basic knowledge in the field (is not necessarily common to the majority of general cardiologists without special expertise in the field)	Requires special knowledge in the field that should be expected from an average candidate passing the exam	Requires special knowledge and/or experience in the field that goes beyond that expected from an average candidate passing the exam	Requires thorough expertise and/or experience in the field

If different criteria lead to different grades, the highest grade should be used.
[a]Can be answered by a 'basic candidate (BC)' (someone passing the exam with just the minimum requirements, i.e. 60%) in percent.
[b]Time to analyse elaborate figures or data by a 'basic candidate' in minutes.

may change from one edition to another, but they should essentially consist of a test with 100–200 multiple-choice questions, with five possibilities being offered of which only one will be correct. These questions will include both academic knowledge and the analysis of traces or practical clinical suppositions and decision-making. The question content is shown in the Syllabus. The number of questions with the purely clinical cardiac electrophysiological and implantable devices content will not be <60%. The average difficulty grade of the exam should be balanced (between 2.5 and 3.5 according to a defined scale shown in *Table 15*). The examinations will be compiled by an Accreditation Committee.

The examination will use specially designed forms for the confidentiality and privacy of the participants, The Accreditation Committee will, at all times, maintain the integrity and confidentiality of the process and will be empowered to invalidate the examination of any candidate if irregularities are detected.

Assessment of professionalism

Assessment of whether the trainee qualifies as a professional or not is important in the evaluation process of the trainee. The 360° assessment is a holistic assessment.[6] Professionals gravitating and with whom the trainee is interacting are prompted by email to answer questions on the trainee. These questions relate to attitude as well as professional aptitudes. Answers are then processed to reveal the trainee's areas of strength and areas for improvement. This method is largely implemented in commercial companies and it should be desirable to implement it in the future. Alternatively to 360° assessment, a simple questionnaire (on team work, etc.) of ~10 questions could be completed by several co-workers (programme director, nurses, surgeons, other trainees, etc.).

Training centre assessment

The Accreditation Committee will announce the period for the submission of accreditation centre applications. Accreditation candidates, whether European or non-European, must submit a standard form, a report on the centre's activities detailing all the merits for patient care, research, and training, and a letter from the national society HR organizations supporting the quality of the training centre and the programme supervisor and the lack of knowledge about inappropriate or unethical conduct.

The Accreditation Committee may organize audits or delegate them to the National Working Groups on HR management, which would act as team of evaluators under the support and expertise of the Accreditation Committee. For this purpose, candidate centres for accreditation by this method must attach a standard signed letter of authorization agreeing to facilitate and cooperate with an eventual audit. The EHRA reserves the right to make formal complaints or accusations within a legal or professional ethics framework as considered necessary in the case of data falsification.

After evaluating the applications, checking the documentation, and performing the corresponding audits, the Accreditation Committee will notify candidates about the result of their application by letter.

Assessment appeals

A period for appeals will be opened after the candidates and the centres are notified of their accreditation application exam result and resolution. The candidate should address his/her appeal or complaint to the Chairperson of the Accreditation Committee.

Reaccreditation and revocation

At its discretion, the EHRA is empowered to revoke accreditation if the accredited professional or centre was not qualified to receive accreditation at the time it was granted. Similarly, accreditation may be revoked if it is proven that the accredited professional or centre acts incompetently or in a professionally or ethically unsatisfactory manner.

The EHRA reserves the right to institute proceedings through all legal and administrative means as deemed necessary in the case of inappropriate use, whether intentional or not, of the denomination 'EHRA Accredited' and its derivatives.

Accreditation committee

Composition

The committee will be composed of 5 to 10 EHRA members (it is advisable that they are accredited), 1 of these being the chairperson of the Committee and, therefore, necessarily a member of the EHRA Board. These members will be appointed by the EHRA Board of Directors. Given that no EHRA members will be accredited when the Accreditation System is initiated, the first Accreditation Committees will be formed by EHRA members with recognized prestige and merit.

Functions

The functions of the Accreditation Committee are as follows:

- Announce and open the period for the call for applications for Accreditation from both professionals and training centres, as well as the management of the same.
- Co-ordinate the degree and diploma verification and audits to evaluate the merits of those professionals and centres applying for accreditation, as well as participation in carrying out the same when deemed necessary.
- Prepare and compose the theoretical examination exercises; maintain a question database for the composition of future theoretical examinations.
- Co-ordinate and manage the theoretical accreditation examination results evaluation.
- Offer and attend any possible appeals from accreditation candidates about the evaluation of the merits they present or the results of their theoretical accreditation examination.
- Submit ratification of accreditation of those candidates who are considered suitable by virtue of the results obtained in the theoretical examination to the EHRA Board of Directors Committee.
- Maintain a register of those who are accredited together with their merits and requisites accomplished.
- Maintain a register of activities and the activities of previous Accreditation Committees.
- Promote and support the organization of training courses.

- Notify the EHRA Board of Directors of any changes in the accreditation system that are deemed necessary to adapt to changes and evolution in HR management.
- Implement any changes that are deemed necessary to adapt the accreditation system to changes and evolution in HR management.
- Co-ordinate this adaptation with those in other national or European accrediting entities, and if considered appropriate, those of non-European international standing.
- Take steps to publicize the accreditation system so it becomes known and can serve as a reference for third parties.
- Keep the EHRA Board of Directors informed about the activities of, the status of, and the changes in the accreditation system.

Frequency of meetings

The Accreditation Committee will hold ordinary meetings at least twice a year. The Secretary to the Committee may call extraordinary meetings at the request of the Chairman of the EHRA Board of Directors for matters of sufficient urgency or importance.

Attendance

Accreditation Committee meetings will always be held with a quorum equal to half the members plus one.

Dependence

The Accreditation Committee will be appointed by and organically dependent on the EHRA Board of Directors.

Elections

Designation for committee members will be held every 2 years, following the elections for the EHRA Board of Directors. With the objective of guaranteeing renewal and a degree of continuity, half of the members should be reelected every 2 years.

Continuous medical education and maintaining competence

Continuous medical education (CME) in cardiology subspecialities are important because knowledge and skills are continuously developing and evolving. Continuous learning and practice are required to maintain standards and practice and because substantial changes may occur in clinical practice or the health-care environment. Training seminars and international specialist conferences must be attended (at least two per year). Courses offered in innovative techniques employed in specialized laboratories should be also attended. Continued practice may indicate 16 h per week working in the subspecialty field. Continued learning may indicate 200 CME credits over a 5 year period in the field of HR management.

Therefore, accreditation as a HR specialist is time limited and will require individuals to go through a process of reaccreditation and recertification. The time period required for reaccreditation will be 10 years or, if considered advisable by the Accreditation Committee, whenever a suitable electronic platform is available. Reaccreditation requires submission and validation of evidence of continued learning and practice within the subspecialty.

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Author	Consulting fees honoraria	Speaker's Bureau	Ownership partnership principal	Research grants	Fellowship support and other benefit
Jose L. Merino	Magnetecs, Medtronic, St Jude Medical, Sanofi-Aventis	Meda Pharma, Medtronic, St Jude Medical, Sanofi-Aventis	None	Magnetecs	Boston Scientific, Medtronic, St Jude Medical
Fernando Arribas	Sanofi-Aventis	Boston Scientific, St Jude Medical	None	None	None
Giovanni Luca Botto	None	None	None	None	None
Heikki Hukuri	None	Biotronik, Medtronic	None	Medtronic	None
Lars I. Kraemer	Medtronic, Sorin Group	Biotronik, Boston Scientific, Medtronic, Sorin Group, St Jude Medical	None	None	None
Cecilia Linde	Medtronic, St Jude Medical	Medtronic, St Jude Medical	None	Medtronic	None
John M. Morgan	None	None	None	None	None
Martin Schalij	Boston Scientific	Biotronik, Boston Scientific	None	Biotronik, Boston Scientific, Medtronic, St Jude Medical	None
Emmanuel Simantirakis	None	None	None	None	None

Continued

Continued

Author	Consulting fees honoraria	Speaker's Bureau	Ownership partnership principal	Research grants	Fellowship support and other benefit
Christian Wolpert	None	Bard, Biotronik, Boston Scientific, Medtronic, St Jude Medical	None	None	None
Marie-Christine Villard	None	None	None	None	None
Julie Poirey	None	None	None	None	None
Svya Karaim-Fanchon	None	None	None	None	None
Keren Deront	None	None	None	None	None

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