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CURRICULUM

Heart Failure Association of the European Society of Cardiology Specialist Heart Failure Curriculum†

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It is well established that organized care of heart failure patients, including specialist management by cardiologists, improves patient outcomes. In response to this, other national training bodies (the UK and the USA) have developed heart failure subspecialty curricula within their Cardiology Training Curricula. In addition, European Society of Cardiology (ESC) subspecialty curricula exist for Interventional Cardiology and Heart Rhythm Management. The purpose of this heart failure curriculum is to provide a framework which can be used as a blueprint for training across Europe. This blueprint mirrors other ESC curricula. Each section has three components: the knowledge required, the skills which are necessary, and the professionalism (attitudes and behaviours) which should be attained. The programme is designed to last 2 years. The first year is devoted to the specialist heart failure module. The second year allows completion of the optional modules of advanced imaging, device therapy for implanters, cardiac transplantation, and mechanical circulatory support. The second year can also be devoted to continuation of specialist heart failure training and/or research for those not wishing to continue with the advanced modules.

Keywords Curriculum • Heart failure • Training

Introduction

Heart failure is increasing in prevalence. This is partly due to the ageing of our population and as a consequence of our better treatment of myocardial infarction. Not only is the number of heart failure patients to be managed great, so is the mortality and morbidity associated with the diagnosis. Heart failure presents both chronically and acutely. It is characterized by frequent and recurrent hospitalizations which are responsible for its huge economic burden on our healthcare systems. Over the last 10–15 years we

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have seen an enormous improvement in heart failure therapy. The range of treatments involves drugs, devices, and surgery. More recent advances will increase the complexity of care for heart failure patients further. This increase in the patient population coupled with the growth in therapeutic options has led to the development of heart failure as a subspecialty of cardiology, in its own right. It differs fundamentally from the other subspecialities in that it is focused on entire disease management rather than being primarily procedure related. The cardiologist with a special interest in heart failure must have a knowledge of all diagnostic and treatment modalities available which goes beyond that demanded by the European Society of Cardiology (ESC) Core Cardiology Curriculum.[1]

Rationale

Heart failure is a complex clinical syndrome—it is essentially the end-stage of all serious forms of cardiovascular disease. All patients with heart failure require a diagnosis of the underlying cardiac condition(s) driving the heart failure and co-morbidities. Subsequent to this, they need therapy directed at the underlying condition as well as the heart failure. That therapy is increasingly complex and spans pharmacology, devices, and surgical therapy. It also has to be delivered as part of a multidisciplinary management strategy which bridges primary, secondary, and tertiary care.

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The programme is designed to last 2 years. The first year is devoted to the specialist heart failure module. The second year allows completion of the optional modules of advanced imaging, device therapy for implanters, cardiac transplantation (CTx), and mechanical circulatory support (MCS). The second year can also be devoted to continuation of specialist heart failure training and/or research for those not wishing to continue with the advanced modules (*Figure 1*).

At present, fulfilment of this curriculum does not guarantee accreditation, which remains within the jurisdiction of the medical licensing authorities of the individual countries. However, satisfactory completion of this curriculum will lead to Heart Failure Association (HFA) certification in heart failure. This is an ideal template for training, and implementation will vary across European countries. As such, it should be adapted according to local needs and possibilities.

Aims of the curriculum

(i) To describe the expert knowledge of heart failure; its causes, natural history, investigation, and treatment required of a heart failure cardiologist.
(ii) To document the skills necessary to deliver optimal heart failure treatment. These skills should all be attained at level III competence (i.e. to be able independently to perform the technique or procedure unaided), unless otherwise stated.
(iii) To summarize the necessary skills required of a heart failure specialist to set up and function as part of a multidisciplinary team, and to deliver heart failure treatment effectively.
(iv) To define the training required for cardiologists with an interest in heart failure to obtain optional advanced skills in:
    (a) Imaging.
    (b) Cardiac rhythm management device implantation.
    (c) Cardiac transplantation (CTx) and mechanical circulatory support (MCS).

Teaching and learning methods

The trainee would be expected to achieve the above learning objectives by rotating to a centre and being attached to a cardiologist with a specific interest in heart failure. During this attachment, they would attend and participate in heart failure clinics and in the inpatient management of heart failure cases (i.e. supervised consultations in outpatients and on ward rounds).

Trainees should be trained in centres with established multidisciplinary heart failure services/networks. During this attachment, they should be able to interact with heart failure nurses and give medical advice to them within locally agreed guidelines (i.e. small group work and multidisciplinary group work).

The trainee would continue to obtain the skills needed for diagnosis and investigation of heart failure by gaining further exposure to transthoracic and transoesophageal echocardiography, and cardiovascular magnetic resonance (CMR) (with rotation to specialist units, if necessary) (i.e. practical opportunities for skill acquisition).

Training opportunities for the selection of patients for device therapy and CTx/MCS can be done locally if sufficient resources exist, or may entail transfer to a high volume tertiary centre ideally for a period of at least 3 months.

Trainees should join the HFA of the ESC, and attend the organized symposia which mirror the curriculum. In addition, they should make an effort to attend either the European or American annual heart failure meetings.

Trainees should be required to undertake two audits per annum of heart failure management. Research into aspects of either clinical heart failure or more basic science heart failure interests would be strongly encouraged.

Assessment methods

Knowledge-based assessment will have been tested after completion of the basic curriculum. The assessment methods for the ESC Specialist Heart Failure Curriculum will be presented separately by the HFA of the ESC, and will probably include the following.

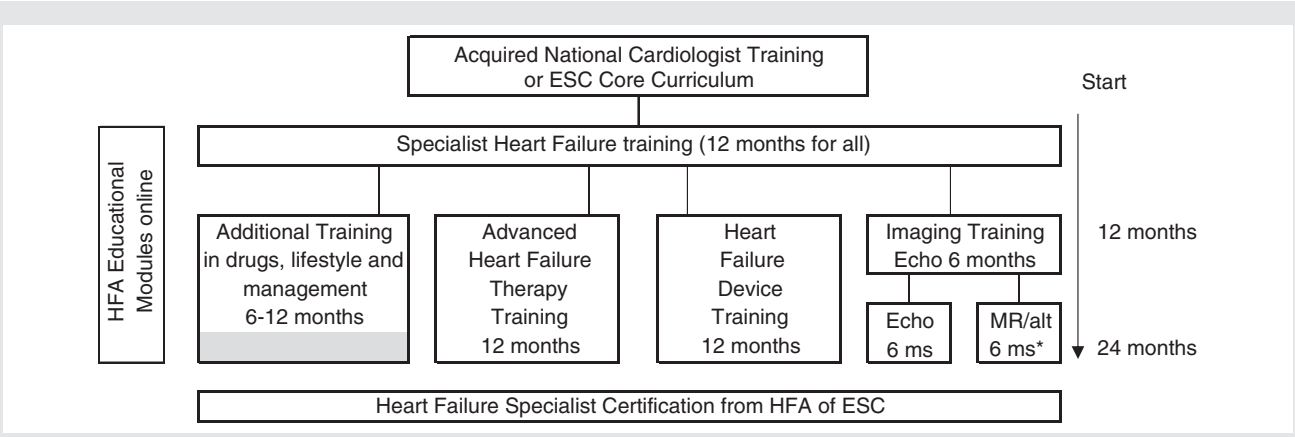

Figure 1 Proposed training programme in heart failure. ESC, European Society of Cardiology; HFA, Heart Failure Association; MR, magnetic resonance; ms, months.

- Further advanced knowledge assessed by online HFA education programme multiple choice questions (MCQs).
- Logbook for all procedures.
- Direct observation of procedural skills. This would apply to:
  - Right and left heart catheterization.
  - Endomyocardial biopsy.
  - Performance and interpretation of transthoracic and transoesophageal echocardiography, and the interpretation of CMR scans.
- Assessment of behaviours using 360 degrees would be suitable for out- and inpatient management, and the ability to function in and lead a multidisciplinary team.
- Competence on the overall management of complex cases could be achieved by case presentations to the supervising consultant, as well as by case note review, and scrutiny of discharge and clinic letters.
- Participation in Continuing Medical Education (CME).

Specific learning objectives

Diagnosis and investigation of chronic heart failure

Knowledge

- Define the clinical presentation, causes, and natural history of heart failure (*Table 1*).
- Expert knowledge of the epidemiology and pathophysiology of heart failure—including both systolic and diastolic dysfunction—and the importance of asymptomatic LV dysfunction as a treatable precursor phase.
- Comprehensive knowledge of national and international guidelines.
- Knowledge of co-morbidities and relevance to supplementary testing.
- Detailed knowledge of all possible underlying causes of heart failure. This should also include a comprehensive knowledge of rarer causes of the heart failure syndrome, including genetic, metabolic, toxic, pregnancy-related, infective, and infiltrative causes (*Table 1*).
- Knowledge of the strengths and limitations of investigative procedures (echocardiography, haemodynamic tests, clinical tests, symptom evaluation, functional capacity, and quality of life measures).
- Knowledge of adverse prognostic markers in heart failure, and familiarity with common prognostic scoring systems (e.g. Heart Failure Survival Score, Seattle Heart Failure Score).
- Knowledge of the indications for investigation for advanced therapies in heart failure [e.g. endomyocardial biopsy, reversibility studies for pulmonary hypertension, cardiopulmonary exercise testing (CPET)].

Skills

Be able to perform a relevant history and examination and interpret appropriate diagnostic tests to define the nature and extent of their cardiac dysfunction and its underlying aetiology:

- 12-lead ECG.
- Routine biochemical tests.
- Heart failure-related biomarkers.
- Genetic testing (where appropriate).
- Transthoracic echocardiography—with respect to regional as well as global dysfunction, LV hypertrophy, valve disease, right ventricular function, indices of diastolic dysfunction, identification of cardiomyopathy, and non-invasive evaluation of haemodynamics including pulmonary pressure.
- Exercise tests, including metabolic testing.
- Basic CMR assessment (level of competence II).
- Coronary angiography.
- Endomyocardial biopsy.
- Left and right heart catheterization.

Table 1 The aetiology of heart failure

Aetiology	Manifestation
Coronary artery disease	Acute coronary syndrome, chronic ischaemia
Hypertension	Heart failure with preserved or reduced systolic function
Valvular disease	Primary (e.g. rheumatic, degenerative, and endocarditic), secondary (e.g. functional regurgitation), or congenital
Dilated cardiomyopathy	Genetic, peripartum, toxic (see below)
Restrictive cardiomyopathy	Genetic, secondary to infiltration
Other cardiomyopathy	Genetic, hypertrophic, ARVC, non-compaction, stress-induced
Arrhythmia	atrial or ventricular brady- or tachyarrhythmias
Infiltrative	Sarcoidosis, amyloidosis, malignancy
Storage disorders	Haemochromatosis, Fabry disease, glycogen storage diseases
Endomyocardial disease	Radiotherapy, endomyocardial fibrosis, carcinoid
Neuromuscular disease	Friedreich's ataxia, muscular dystrophy
Infective	Myocarditis, Chagas disease, HIV
Drugs	Cytotoxic therapy (e.g. chemotherapy), anti-arrhythmics
Toxins	Alcohol, cocaine, trace elements (mercury, cobalt, arsenic)
Endocrine	Thyrotoxicosis, acromegaly, phaeochromocytoma
Nutritional	Thiamine deficiency (Beri-beri), selenium deficiency
Pericardial disease	Calcification, infiltrative
High output	Anaemia, AV fistulae

ARVC, arrhythmogenic right ventricular cardiomyopathy; AV, arteriovenous; HIV, human immunodeficiency virus.

- 24-h Holter monitoring.
- Ambulatory blood pressure monitoring.
- Nuclear imaging (level of competence II).

Be able to investigate for, and refer patients on as appropriate:

- Sleep-disordered breathing.
- Specific heart muscle disorders (*Table 1*).
- Myocardial viability.
- Advanced heart failure therapies.

Professionalism

- Recognize the importance of establishing an underlying aetiology with the least invasive test necessary at each stage.
- Understand issues of cost-effectiveness, availability, and rationale for choosing appropriate tests.
- Understand the pivotal role of an accurate diagnosis in planning future investigation and therapy.
- Effective communication with the patient, family, referring physicians, and caregivers regarding diagnosis, diagnostics, and treatment options.

Treatment of the underlying aetiology

Knowledge

- Comprehensive knowledge of the management and prevention of coronary heart disease, hypertension, and valve disease and other causes (*Table 1*).
- Detailed knowledge of risk factor management and pharmacology according to current guidelines.

Skills

- Identification and correction of reversible causes.
- Choose optimal treatments for risk factors.
- Selection of patients for revascularization based on accurate interpretation of invasive and non-invasive testing.
- Appropriate selection of patients for valve procedures.

Professionalism

- Appreciation of the need for treatment of the underlying cause as to the potential 'reversibility' of heart failure.
- Ability to liaise with and discuss optimum management with patients and healthcare professionals, in particular with cardiac surgeons, internists, general practitioners (GPs), specialist prevention nurses, and interventional cardiologists.

Diagnosis and treatment of co-morbidities

Knowledge

- Expert familiarity of common co-morbidities in heart failure and their impact on presentation, prognosis, investigation, treatment choice, and efficacy (*Table 2*).
- Be conversant with drug interactions resulting from treatment of co-morbidity.

Skills

- Perform and interpret appropriate diagnostic tests for co-morbidities.
- Basic management of co-morbid conditions.

Table 2 Common non-cardiac co-morbidities in patients with heart failure

Anaemia and iron deficiency
Arthritis
Cancer
Cerebrovascular disease
Chronic kidney disease
Cognitive disorders
Depression
Diabetes mellitus
Erectile dysfunction
Gout and hyperuricaemia
Hepatic dysfunction
Obstructive lung disease
Sleep-disordered breathing
Thyroid abnormalities

- Refer for specialist advice where indicated.
- Outline a plan for continuation of drug therapy for patients undergoing non-cardiac surgical procedures.
- Define the most rational heart failure treatment strategy taking into account existing co-morbidities.

Professionalism

- Understand the impact of co-morbidities on the patient's comprehension of their heart failure and its treatment.
- Promote multiprofessional input to patient management.
- Foster a team approach to the management of the patient and their family and carers.
- Communicate effectively with other healthcare professionals managing co-morbidities (i.e. GPs, care of the elderly physicians, internists, nephrologists, haematologists, psychiatrists, pulmonologist, and relevant specialist nurses).

Medical treatment of heart failure

Knowledge

- Detailed and expert knowledge of current treatment guidelines [ESC and American Heart Association/American College of Cardiology Foundation/Heart Rhythm Society of America (AHA/ACC/HRS)],[5] from prevention to treatment of end-stage heart failure.
- Familiarity with evidence-based pharmacotherapy for heart failure with the heart failure treatment trials, including efficacy, effects on morbidity and mortality, side effects, and contraindications.
- Be conversant with major ongoing trials of emerging therapies.

Skills

- Discuss the complicated therapy regimes with the patient; outline the plan for therapy.
- Be able to interpret critically clinical trials of heart failure drugs.
- Tailor heart failure disease-modifying therapies to the individual and their stage of disease, including cessation and down-titration of drugs if necessary.

Professionalism

- Interaction with the multidisciplinary team to deliver the therapy, up-titrate drugs, and monitor for side effects. In particular, close communication with specialist heart failure nurses, pharmacists, and primary care physicians.
- Effectively communicate the management plan with patients and their carers.
- To educate patients as to the treatment options open to them and explain the strategy.

Lifestyle

This section includes: salt, fluid, and weight management, physical activity, driving, travel, sex, immunization, rehabilitation palliative care, self-management, smoking and alcohol, and employment.[6]

Knowledge

- Critical appraisal of clinical research about lifestyle and non-pharmacological interventions and its translation to clinical practice.
- Importance of individually tailored lifestyle intervention and advice.
- Prevention of most common lifestyle-related deterioration triggers.
- Self-care strategies.
- Familiarity with physical activity and rehabilitation modalities.
- Familiarity with quality of life instruments.
- Be aware of differences between patient knowledge, skills, and devices needed to perform self-care management.

Skills

- Organize, supervise, and update patient education activities.
- Be able to interact with lay public and patient carers.
- Be able to interpret (patho)physiological consequences of non-adherence to lifestyle measures for the patient.
- Instruct patients how to keep a healthy weight and be able to interpret weight change in light of disease progression and patient symptoms.
- Be able to educate patients and their relatives on warning signs, side effects, and potential risk of antithrombotic use.
- Ability to organize/initiate patient-guided management groups.
- Adjust lifestyle and self-care advice to the individual patient and home circumstances.
- Set realistic goals and ability to plan non-pharmacological management.
- Give patient-centred physical activity advice to maintain physical activity.

- Increase adherence to treatment recommendation and facilitate implementation of lifestyle advice and self-care behaviour.
- Empower patients to cope with lifelong disease.
- Promote healthy lifestyle regarding habits, travel, and sexual activity.

Professionalism

- Proficient level of communication with patients and carers.
- Ability to liaise with nurses, GPs, and psychologists.
- Be aware of discrepancy between physiologically plausible effects and available evidence.

Device therapy for heart failure

Knowledge

- Accurate selection of suitable patients for CRT and defibrillator therapy based on evidence-based medicine and knowledge of international and local guidelines.
- Have an understanding from the core curriculum of bradycardia pacemaker implantation and programming.
- Be highly conversant with the complications that can occur acutely following device therapy, and in the medium/long term.
- Have detailed knowledge of how defibrillators and CRT pacemakers function and are programmed. Be aware of how such devices can be used for remote monitoring.
- Be highly conversant with the type and treatment of arrhythmias which occur in heart failure.
- Have knowledge of the potential effects of electromagnetic interference on device therapy.
- Have knowledge about the indications for atrioventricular (AV) node ablation following CRT.

Skills

Be able to:

- Interpret 12-lead ECG, 24-h Holter monitoring, and other arrhythmia screening tools (e.g. implantable loop recorders).
- Deactivate defibrillator therapy and pacemaker functions.
- Perform basic device troubleshooting.
- Identify non-responders to CRT.
- Manage patients post-device therapy ensuring maximum biventricular pacing is achieved and that patients have their medication optimized and adjusted post-CRT.
- Be familiar with the intracardiac electrogram (EGM) recordings obtained from devices.
- Consent/advise a patient in a balanced and informed way about the success rates, risks, and benefits of CRT and to be able to discuss alternatives, e.g. epicardial lead implantation.

These skills should be acquired by:

- Attending heart failure clinics at which patients are selected for complex device therapy (minimum number: 50 patients).
- Observing the implantation of 10 CRT and 30 ICD devices (level of competence I).
- Demonstration that trainees have participated in post-CRT follow-up clinics, where:
  - CRT and ICDs are interrogated and their programme settings optimized (50 patients—level of competence II).
  - Echocardiography is used to set AV [± ventriculoventricular (VV)] delays for CRT (>5 patients).
  - Drug therapy is optimized post-CRT (>30 patients).

Professionalism

- Ability to communicate and liaise with other healthcare professionals, in particular electrophysiologists and physiological measurement technicians.
- To foster a team approach to pacing.
- To educate patients (and their families/partners) as to the treatment options open to them and to explain treatment strategies.
- To appreciate the psychological impact of the patient's illness on the patient and their family and to manage it sensitively.

Monitoring of heart failure patients

This includes medical follow-up, self-monitoring, telemonitoring, and haemodynamic monitoring.

Knowledge

- Detailed and expert knowledge of strengths and limitations of modalities for monitoring patients to identify and prevent worsening of heart failure.
- Familiarity with ways of monitoring patients by means of weight, symptoms, biomarkers, echocardiography, implanted devices, and functional tests such as 6 min walk test (6MWT) and CPET.
- Be conversant with new modalities (e.g. use of telemedicine, implantable devices and their parameters, and biomarkers for monitoring of patients).

Skills

- Discuss the possibilities of monitoring with the patient, outline the plan for reporting of warning signs, and be able to consider suitable follow-up intervals.
- Be able to plan and interpret critically programmes for monitoring patients.
- Be able to detect deterioration of patients, and treat appropriately.

Professionalism

- Interaction with the multidisciplinary team to interpret monitored variables.
- To educate patients and their carers effectively as to the monitoring options open to them and explain the strategy.

Acute heart failure

Acute heart failure (AHF) is defined as a rapid onset of signs and symptoms of pulmonary congestion and/or peripheral hypoperfusion, resulting in the need for urgent therapy. It is a highly heterogeneous syndrome including acute decompensation of chronic heart failure or *de novo* presentation. It remains a challenge for clinicians and, paradoxically, AHF treatment remains empirical due to the paucity of randomized clinical trial data. This module is intended to build upon knowledge and skills gained in the heart failure section of the core curriculum.

Knowledge

- Epidemiology, pathophysiology, and prognosis of AHF syndromes.
- Familiarity with the different phenotypes of the classification of AHF syndromes: a spectrum of conditions ranging from life-threatening pulmonary oedema or cardiogenic shock to a condition characterized, predominantly, by worsening peripheral oedema.
- Knowledge of the investigations for AHF, and their limitations.
- Diagnosis and investigation of AHF phenotypes (*Table 3*).
- Evaluation of prognosis.
- Knowledge of AHF treatment and management goals from randomized trials and guidelines (*Table 4*).
- Awareness of limitations in evidence for AHF.
- Precipitating factors that predispose to chronic HF exacerbations or cause *de novo* symptomatology.

Table 3 Clinical and laboratory evaluation of suspected acute heart failure

Initial evaluation
Known history of heart disease or prior heart failure
Physical examination (assessment of peripheral and pulmonary congestion, evaluation of peripheral perfusion)
Abnormal ECG
Chest X-ray abnormalities
Blood gas analysis/oxygen saturation
Blood chemistry (markers of liver and/or kidney injury)
Full blood count
Plasma levels of natriuretic peptides, and other biomarkers (e.g. troponin)
Echocardiography (plus conventional Doppler or tissue Doppler imaging technique)
Assessment of aetiology and severity by selected investigations, and planning of treatment
Right heart catheterization, if indicated
Coronary angiography, if indicated
MRI
Other techniques (e.g. CT scan) according to the clinical suspicion

CT, computed tomography; MRI, magnetic resonance imaging.

Table 4 Goals of treatment in acute heart failure (modified from European Society of Cardiology guidelines)[4]

(a) Immediate (ER, ICU, CCU)
Alleviate symptoms
Improve oxygenation
Increase peripheral organ perfusion
Improve central haemodynamics
Avoid vital organ damage
Achieve clinical stabilization and optimization of i.v. therapies
Limit ICU/CCU length of stay
(b) Intermediate (Cardiology ward)
Start and, where appropriate, up-titrate oral life-saving chronic medications (e.g. ACE inhibitors, beta-blockers, MRAs)
Detect the subpopulations that need CRTs and/or ICDs
Minimize the length of in-hospital stay
(c) Pre-discharge and long-term management
Optimize pre-discharge fluid status
Ensure clinically stable
Refer to outpatient heart failure clinic and cardiac rehabilitation centre
Educate and give instructions for lifestyle modification
Prevent new heart failure exacerbations
Support psychosocial status
Improve quality of life and prognosis

ER, Emergency Room; CCU, Coronary Care Unit; ICD, implantable cardioverter defibrillator; ICU, Intensive Care Unit; MRAs, mineralocorticoid receptor antagonists.

Skills

- Full evaluation of patients: history, physical examination, 12-lead ECG, biomarkers, electrolytes, basic biochemical tests, blood gas analysis, chest radiography, including the limitations of diagnostic tests.
- Evaluation of precipitating causes.
- Ability to perform and evaluate a comprehensive echocardiographic examination.
- Perform, interpret, and be aware of the limitations of right heart catheterization.
- Be familiar with other methods of invasive and non-invasive haemodynamic monitoring.
- Decide on the use of appropriate therapies: loop diuretics, opiates, nitrates, inotropes, fluid and electrolyte management strategies, circulatory and respiratory support, renal replacement therapies.
- Familiarity with the indications for the use of non-invasive ventilatory devices.
- Treat precipitants: drugs, infection, ischaemia, arrhythmia, and other reversible factors.
- Consider the use and potential modification of conventional chronic heart failure medication.
- As a minimum, trainees should be familiar with indications for and use of an intra-aortic balloon pump (IABP). Ideally, trainees should be skilled in the insertion of an IABP.

- The ability to discuss indications for haemodynamic support with other short-term MCS for complicated myocardial infarction, cardiogenic shock, and other severe conditions.
- Be familiar with the indications and use of portable peripheral ultrafiltration devices.
- Be able to identify those who require a more palliative approach.

Professionalism

- Ability to communicate and liaise with other healthcare professionals, in particular with intensivists, emergency medicine specialists, internists, nephrologists, surgeons, and chest physicians
- Particular skills in communicating with the acutely ill patient and their relatives/carers, to appreciate the psychological impact of the patient's illness on them and their family and to manage it sensitively.
- To foster a team approach.
- To audit outcomes.

Functioning as part of a multidisciplinary team

Knowledge

- Be able to define a multidisciplinary service/network.
- Be aware of the evidence base underpinning their pivotal role in heart failure management.
- Familiarity with international, national, and local guidelines for heart failure management.

Skills

Be able to:

- Set up and function as part of a multidisciplinary team.
- Set up and run a heart failure clinic.
- Organize and chair multidisciplinary meetings to discuss patient care.
- Give an opinion to other consultant colleagues on heart failure issues.
- Write and amend guidelines for local heart failure management.
- Construct business cases for service developments in heart failure.
- Function as a clinical lead for heart failure within the consultant cardiology body in the institution.
- Set up, organize, and run continuing educational development programmes in heart failure for the local team.

Professionalism

- Ability to communicate and interact with other members of the multidisciplinary team: heart failure nurses, care of the elderly and general physicians, primary care physicians, palliative care services, and pharmacists.
- Foster an approach which spans the patient's journey, i.e. to be able to co-ordinate care in the primary, secondary, and tertiary care sectors.

The above skills should be achieved by a trainee being attached to a cardiologist who is leading a multiprofessional heart failure team for a period of at least 6 months.[7] During that time, he/she should attend multidisciplinary team meetings (at least 25), nurse-led heart failure clinics (20), have experience in inpatients and outpatients with a care of the elderly physician (10 ward rounds and 10 clinics), and participate in clinics in primary care (run by GPs and specialist nurses).

Special modules

Advanced imaging: echocardiography and cardiovascular magnetic resonance

This module describes the requirement for a trainee who has completed the general heart failure programme and wants to prove competences in heart failure-related imaging.

Imaging, and in particular echocardiography, is a major contributor in evaluating the cause and mechanism of heart failure. Treatment and management of heart failure are a direct consequence of an accurate interpretation of this examination. Therefore, heart failure specialists with advanced competences in imaging are required. However, echocardiography remains an operator-dependent technique, so the applicant must possess thorough knowledge of cardiac anatomy and pathophysiology together with appropriate technical skills.

Echocardiography is the first-line investigation for assessment of cardiac anatomy, function, and dynamics. However, image quality is poor in some patients, and a multimodality approach is often necessary with use of contrast echo or CMR. Applicants may choose to specialize further in imaging with focus on either echocardiography or CMR.

CMR provides accurate quantification of systolic dysfunction, and may help in determining aetiology, prognosis, and therapy. CMR has the key advantage of tissue characterization and perfusion imaging. However, CMR is not suited for anatomical assessment of patients with potential coronary disease, where cardiac computed tomography (CT) or percutaneous coronary angiography is preferable. A CMR module for a heart failure cardiologist should allow the doctor to report adult CMR scans on patients with heart failure syndromes.

Knowledge

- Have a detailed knowledge of the various imaging techniques to select accurately the optimal imaging method for identifying the cause and mechanism of heart failure.
- Be able to use the full range of widely used and validated diagnostic capabilities to identify the nature and establish the severity of cardiac diseases in order to guide clinical management of patients.

Table 5 Echocardiographic modalities and knowledge

Assessment of diameters, volumes, and mass
Non-invasive haemodynamics derived from echo-Doppler
Assessment of volume and flow measurement, normal antegrade intracardiac flows, assessment of intracardiac pressures, continuity equation, pressure half-time method, proximal isovelocity surface area (PISA), contractility assessment (d*P*/d*t*)
Assessment of systolic function
Determinants of LV performance, global LV systolic function, regional systolic function, interdependence of left ventricle and right ventricle, global right ventricular systolic function, speckle tracking for global strain
Assessment of diastolic function
Echo-Doppler approach to LV diastolic function
Assessment of cardiomyopathies (*Table 1*)
Assessment of valvulopathies and artificial valves
Stress echocardiography, basic principles
Transoesophageal echo, basic principles
Contrast echocardiography and tissue harmonic imaging, basic principles
Real-time three-dimensional echocardiography, basic principles
Tissue Doppler and speckle tracking, basic principles
Principles of quality assessment in echocardiography, basic principles

The items refer to the core syllabus for the accreditation in transoesophageal echocardiography by the EAE, where a more detailed description may be found.[8]

- Have a detailed knowledge of the phenotype of different aetiologies, and factors indicating potentially reversible factors.
- Heart failure/echo specialists should have a more comprehensive understanding of the techniques (*Table 5*), and be able to perform and to supervise in the listed modalities.
- Heart failure/CMR specialists should have a more comprehensive understanding of the techniques (*Table 6*), and be able to perform and to supervise in the listed modalities.

Skills

- Advanced interpretation of echocardiography or CMR.
- To refer relevant patients for CMR, advanced echocardiography, radioisotope examinations, coronary angiography, and cardiac CT.
- Demonstration that trainees have participated in the work-up of patients with all of the aetiologies of heart failure (*Table 1*).
- Obtain accreditation in transthoracic echocardiography (EAE or national equivalent), and be a competent independent operator in echocardiography, or level III competent in CMR.[8]

These skills should be acquired by working in the imaging section of an accredited high-volume tertiary centre for a full-time period of at least 12 months. This can be achieved at the same time as competencies for the general module. For trainees wishing to have experience in two imaging modalities, it is suggested that this would include at least 6 months echocardiography, and CMR [or an alternative imaging modality such as CT, nuclear, positron emission tomography (PET)] for at least 3 months.

Trainees opting for an advanced echo module should achieve the relevant competencies (European/national) in transoesophageal echocardiography and stress echocardiography. Similarly the relevant advanced CMR competencies should be achieved for those opting to have CMR as their major imaging specialty. Applicants choosing to specialize in CMR need to have acquired the basic echocardiographic skills in the core curriculum.

Professionalism

- Recognize the importance of rational use of imaging for diagnosis, prognostication, treatment, and follow-up.
- Present and discuss imaging with surgeons, interventionalists, and other physicians involved with the patient management.
- Be able to lead multidisciplinary imaging meetings.
- Participate in regular audit.
- Be able to consent patients appropriately for imaging techniques and to discuss with them the results of investigations.

Device therapy for implanters

This module describes the requirement for a trainee who has completed the general heart failure programme and wants to pursue competencies in device therapy.

Although in many European countries devices are implanted by electrophysiologists or surgeons, there are a growing number of countries where heart failure cardiologists implant ICDs (implantable cardioverter defibrillators) and CRT. Therefore, this module describes the knowledge, skills, and professionalism required for a heart failure cardiologist to be able to implant complex devices.

It is envisaged that this optional module would require at least 12 months to complete, and would involve training in a certified, high-volume pacing centre.

Knowledge

Building on the knowledge already obtained in core cardiology training, and with competences achieved in module 6, device implanters should have:

- An excellent working knowledge of the principles of pacing, cardiac and thoracic anatomy, and the conduction system and its disease processes (*Table 7*).
- A full appreciation of the indications for pacing/ICD/CRT therapy, as well as the complications that may arise (and subsequent solutions required) is needed.
- An excellent working knowledge of the existing and emerging lead/device technology and, in particular with respect to CRT, the importance of lead and target vessel selection.

Skills

- Correct patient investigation and selection for appropriate device therapy.
- Have already achieved basic competency in device therapy (core curriculum).

Table 6 Cardiac magnetic resonance modalities and knowledge[9,10]

CMR technique
Safety with most sternal wires, cardiac prosthetic valves, and stents. Currently no safety with the majority of ICDs and pacemakers, and intracardiac clips
Safety if eGFR >30 mL/min
Volume, mass, and function study, basic principles
LGE imaging to assess myocardial scar after infarction, cardiomyopathy, or myocarditis
Additional techniques
Myocardial blood velocities/flow for evaluation of shunts, valve disease, and congenital heart disease
Cardiac iron quantification for iron overload (e.g. thalassaemia)
T2-weighted imaging for oedema in acute myocarditis, sarcoidosis, and infarction
T1-weighted imaging for pericardial disease, masses, and myocardial fat in ARVC
Tagging for pericardial disease and diastolic function
Real-time imaging during respiration for diaphragm paralysis and pericardial constriction
Stress imaging for vasodilator or inotropic stress for ischaemia/viability
Tissue characterization for inherited cardiomyopathies such as Fabry, dilated cardiomoypathy, hypertrophic cardiomyopathy, ARVC, and non-compaction.
Tissue characterization in acquired cardiomyopathies due to amyloidosis, sarcoidosis, myocarditits, iron overload, eosinophilic disease, and Chagas disease
Tissue characterization of cardiac tumours
Early post-contrast imaging (LGE) for thrombus and microvascular obstruction
LGE for perfusion, viability imaging, and to predict responsiveness of revascularization and biventricular pacing
High quality imaging of the valve anatomy when echo acoustic image is poor

ARVC, arrhythmogenic right ventricular cardiomyopathy; CMR, cardiac magnetic resonance; eGFR, estimated glomerular filtration rate; ICD, implantable cardioverter defibrillator; LGE, late gadolinium enhancement.

- Have an aptitude for safe implantation of device therapy, using aseptic techniques, and with suitable use of the cephalic, subclavian, and axillary approaches.
- Manage peri-operative anticoagulation appropriately (e.g. mechanical valves).
- Have an acceptably low complication rate, and have experience managing complications.
- Be able to program ICDs, to minimize right ventricular pacing (except for CRT where devices should be programmed to maximize biventricular pacing), provide zones for antitachycardia therapy, and appropriately select algorithms for discrimination of ventricular tachycardia (VT) and supraventricular tachycardia (SVT).
- Advanced troubleshooting is also required to identify lead or device malfunction, inappropriate therapy, or subsequent need for ablation (e.g. for AF).

These skills should be acquired by:

- Attending heart failure clinics at which patients are selected for complex device therapy (minimum number: 75 patients).
- Implanting a minimum of 100 pacemaker systems as first operator.
- Implanting a minimum of 25 ICD systems as first operator (2014 target by EHRA[11]).
- Implanting a minimum of 30 CRT systems as first operator (2014 target by EHRA[11]).
- Demonstrating experience managing complications of pacing:
  - Pericardiocentesis.
  - Pleural aspiration/chest drain.
  - Wound management.
  - Avoidance of phrenic nerve stimulation by programming or lead remanipulation.
- Demonstration that trainees have participated in post-CRT follow-up clinics, where:
  - CRT/ICDs are interrogated and their programme settings optimized (75 patients).
  - Echocardiography is used to set AV (±VV) delays for CRT (50 patients).
  - Drug therapy is optimized post-CRT (50 patients).

Professionalism

- Ability to communicate and liaise with other healthcare professionals, in particular electrophysiologists and physiological measurement technicians.
- To foster a team approach to pacing.
- To educate patients as to the treatment options open to them and to explain treatment strategies.
- To appreciate the psychological impact of the patient's illness on the patient and their family and to manage it sensitively.
- To audit long-term complications.

Whilst a minimum number of devices are recommended, implanters develop their technical skills at different rates. As such, it is of particular importance that trainees get as much exposure as possible to all aspects of device therapy.

Table 7 Knowledge, skills, and professionalism expected for both the heart failure doctor and device implanter

Knowledge		Core knowledge	Device implanter
Anatomy	Cardiac anatomy	X	X
	Conduction system	X	X
	Central venous system	X	X
	Coronary sinus		X
Pathology	Conduction system disease	X	X
Technology	Principles of pacing	X	X
	Lead and battery technology	X	X
Programming	Programming pacing mode	X	X
	Switch off defibrillator component	X	X
	Assess degree of RV/BiV pacing	X	X
	Interrogation of electrograms (EGMs)		X
	ICD discriminators		X
Skills	Aseptic technique/antibiotic regime	X	X
	Appropriate local anaesthesia		X
	Safe approach to gain access from axillary, cephalic, or subclavian vein		X
	Safe implantation of lead and device with acceptably low complication rate		X
	Management of lead problems		X
	Managing complications, e.g. tamponade	X	X
	Competence troubleshooting and programming of devices (including echo optimization of CRT)	X (basic programming)	X (advanced programming)
Professionalism	Correct attitude to surgical approach		X
	Foster a team approach		X
	Audit long-term complications		X
Key competences	Pacemaker systems		Implant >100
	ICDs	Observe >3	Implant >25
	CRT	Observe >5	Implant >30
	Assessment clinics for device therapy	>50 patients	>75 patients
	Follow-up clinics to optimize medical therapy	>50 patients	>50 patients
	Echo optimization	>5 patients	>50 patients

BiV, biventricular; EGM, electrogram; ICD, implantable cardioverter defibrillator; RV, right ventricular.

Module for cardiologists caring for patients undergoing cardiac transplantation and mechanical circulatory support[12,13]

This module describes the requirement for a trainee who has completed the general heart failure programme and wants to pursue competencies in advanced heart failure management.

It is envisaged that this optional module would require at least 12 months to complete, and would involve training in the assessment of patients for, and management following, CTx and MCS in a certified, high-volume centre.

Knowledge

- Epidemiology and pathophysiology of advanced heart failure.
- Anatomy and pathophysiology of the transplanted heart.
- Indications (common and uncommon) for CTx/MCS implantation (short- and long-term, left and right ventricular assist devices).
- Contraindications to CTx and MCS therapy.
- Detailed knowledge of the INTERMACS registry data, and how these relate to outcome following MCS.
- Prognostic markers in advanced heart failure and the outlook for medical, CTx, and MCS therapy.
- Technical characteristics of MCS devices.
- Post-operative and long-term complications of CTx and MCS therapy.
- Graft rejection and post-operative care for CTx and MCS patients.
- Psychological adaption of patients post-CTx and MCS implantation.
- Rehabilitation post-procedures.
- Palliative care for advanced heart failure.
- Multiprofessional approach to selection and aftercare of CTx and MCS patients.

Skills

- Assess, select, and de-select patients for CTx and MCS therapies.

- Plan pre-CTx assessment and co-ordinate and supervise the pre-CTx phase including repetitive invasive examination.
- Interpretation of CPETs.
- Perform survival scores (Heart Failure Survival Score and Seattle Heart Failure Model).
- Perform a comprehensive right ventricular dysfunction evaluation (including right heart catheterization measurements, strategies for the reversal of pulmonary hypertension, and non-invasive markers of severity of right ventricular dysfunction).
- Manage anticoagulation in patients receiving MCS.
- Perform an evaluation of nutritional status.
- Manage post-operative complications.
- Use of immunosuppressive drugs.
- Perform and interpret cardiac biopsy for allograft rejection.
- Function as part of, and be able to lead, a multidisciplinary team.

These skills should be acquired by:

- Attending CTx/MCS clinics at which patients are selected for advanced therapy (minimum number: 50 patients).
- Managing patients who have undergone CTx (at least 15, of whom at least 10 are seen during initial transplant hospitalization as well as pre-operative and post-operative management).
- Managing patients with heart failure on MCS (at least 15, of whom at least 10 are being managed during peri-operative hospitalization as well as on an outpatient basis).

Professionalism

- To understand the effects of CTx and MCS assessment and treatment on the patients and their carers.
- Ability to communicate and collaborate with other healthcare professionals, in particular cardiothoracic surgeons, intensivists, palliative care providers, MCS technicians, and specialist nurses.
- Explain the advantages and disadvantages of these advanced heart failure therapies to patients and their carers.
- Foster and guide a multidisciplinary team approach.
- Educate patients and their carers on post-operative MCS and CTx care.
- Understand the need for relevant rehabilitation programmes and patient psychosocial support and to be able to facilitate provision of this care.
- Audit short- and long-term complications.

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