

ESC Core Curriculum for the General Cardiologist (2013)

European Society of Cardiology

Committee for Education

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Preface

The previous Core Curriculum for the General Cardiologist defined a model for cardiology training in Europe and it has been adopted as the standard for regulating training, for access to the specialty (certification), and for revalidation in several countries.¹

During the last 5 years we have witnessed profound changes in cardiological practice. The work of both hospital and independent cardiologists has been better integrated with that of general practitioners. It has taken into account the requirements of national authorities, re-imbusement organizations, and hospital administrations. Cardiologists face changing patient expectations. General cardiologists, interventional cardiologists, anaesthetists, and cardiac surgeons work together in Heart Teams.^{2,3} The age of cardiac patients has increased and they are presenting with more co-morbidities. Knowledge, technology, and treatment are constantly advancing: new imaging modalities have become widely available. Stent technology has evolved and competes with cardiac surgery for all but complex cases.² Percutaneous valve implantations are increasingly successful.⁴ Interventional electrophysiology and device therapy have become cornerstones in the practice of cardiology.^{5,6} Care of the patient with heart failure is now a multi-disciplinary undertaking.⁷ New powerful anti-thrombotic and anticoagulant therapies have been introduced and are often used in combination, with clear benefits but increased bleeding risks.^{6,8,9} Use of diagnostic and therapeutic tools and the approaches to management of common conditions have been systematically clarified in regularly updated ESC consensus guideline documents.

Against the background of these developments, the Board of the ESC decided in 2011 to revise and update the Core Curriculum. The chairman of the Committee for Education 2010–2012, Otto A. Smiseth,

delegated this project to a task force, whose members were drawn from general cardiologists. The 2013 version of the Core Curriculum outlines the knowledge and skills of the general clinically oriented cardiologist, rather than those required for the sub-specialties. The document provides a framework for training and certification, continuous medical education (CME), and recertification.

The Core Curriculum will inevitably continue to evolve as authors and reviewers are aware that there are still important differences in training and means throughout Europe and ESC member states. In the Core Curriculum, the ESC is setting a standard that national societies can use in their dealings with political institutions and national authorities. A deliberate decision was taken to outline an optimal rather than a minimum standard, allowing for the fact that not every training system will be able, or may not wish, to adopt the full curriculum. In countries (or centres) that are currently unable to deliver training in all its aspects, the Core Curriculum can and should be used as a benchmark to promote improvement.

The 2013 Core Curriculum defines the clinical, patient-oriented, training of the general cardiologist. The overall structure of the previous version has been retained, but the table format has been abandoned to limit the number of printed pages and to make the document more easily searchable on-line. In most subject areas, there was a wide if not unanimous consensus among the task force members on the training required for the cardiologist of the future. The document recommends that acquisition of competence in general cardiology requires at least 6 years of full-time postgraduate training, of which 4 years are devoted to cardiology.

The general aspects of training and all individual chapters have been updated. The document focuses on knowledge of mechanisms of disease, clinical and communication skills, empathy for the patient and their relatives, and teamwork. A clear boundary has been set between the competencies required of the general cardiologist and those of the sub-specialist.^{10–13} The first part of the curriculum covers general aspects of training, and is followed by a comprehensive description of the specific components in 28 chapters. Each of the chapters includes statements of the objectives, and is further subdivided into the required knowledge, skills and behaviours, and attitudes.

Some chapters have been renamed and/or sub-divided into sub-sections. The most salient changes are summarized here. Non-invasive imaging (Chapter 2.3) has been divided into five sections: Non-invasive imaging (general aspects), Echocardiography, Cardiac magnetic resonance (CMR), Cardiac X-ray computed tomography, and Nuclear techniques. Cardiovascular prevention (Chapter 2.7) has been divided into sections on Cardiovascular risk factors and Arterial hypertension. Cardiac tumours (Chapter 2.12) has been replaced by a new and broader chapter on Oncology and the heart. The chapter Cardiac Rehabilitation and Exercise Physiology (Chapter 2.19) has become Physical activity and Sport in primary and secondary prevention and includes sections on Sports cardiology and Cardiac rehabilitation. A new chapter entitled Acute cardiovascular care (Chapter 2.27) has been added. The Cardiac consult (Chapter 2.28) has been expanded and divided into sections dealing with the patient undergoing non-cardiac surgery, the patient with neurological symptoms or diseases, and the patient with conditions not presenting primarily as cardiovascular disease

[elderly patients, patients with diabetes, chronic kidney disease (CKD), erectile dysfunction, and others].

The 2013 Core Curriculum underwent a thorough review process based on the template of the review of the ESC guidelines. The document does not include minimum or optimal numbers of procedures to be undertaken, and does not address periodic evaluation, certification, or revalidation. This does not obviate the importance of regular, structured, and formally documented assessment, which is crucial to implementation of the curriculum. This should include knowledge-based assessments (formative and summative), formally observed procedures and practices, a log-book, and a recognition of the potential of simulation techniques in both training and assessment.

Part 1: The Core Curriculum for the General Cardiologist

1.1 The general cardiologist and his clinical field

The clinical specialty of cardiology aims to deliver expert care for patients presenting with disorders of the heart, the systemic, and the pulmonary circulations. This Core Curriculum provides the standards for training in general cardiology, as well as a template for the maintenance of competence for qualified cardiologists.

Completion of the curriculum in general cardiology should equip the trained cardiologist with the knowledge, skills, behaviours, and attitudes to act independently as an expert in the

- diagnosis, assessment, and management of cardiovascular emergencies;
- diagnosis, assessment, and management of patients referred from primary care or other medical specialties with known or suspected disorders of the heart and circulation; and
- risk assessment and the prevention of cardiovascular disease in their community and in their patients.

The ability to apply knowledge to clinical problems requires mastery of the indications for, and the performance and interpretation of cardiological investigations, treatments, and procedures. It further demands a depth of knowledge and experience of the sub-specialties sufficient to ensure the appropriate referral for more advanced investigations and therapies.

The content of the 2013 Core Curriculum is inspired by the most recent ESC Guidelines for Clinical Practice.^{4,6,7,9,14,15} These guidelines constitute an authoritative, comprehensive, and updated library of cardiac evidence-based medicine. The previous version of the Core Curriculum was an important source of information for the structure and content of the European Textbook of Cardiology.

The general cardiologist is a medical specialist with a thorough basic training in internal medicine, experience of which is particularly relevant in the fields of intensive care, pulmonary diseases, kidney diseases, diabetes care, and care for the elderly. The most common cardiovascular diseases are consequences of atherosclerosis, arterial hypertension, ageing, heart failure, and rhythm or conduction disturbances. Cardiologists will often have to be involved (in collaboration

with the general practitioner and other care providers) in the global care of patients, beyond their primary responsibility for diseases of the heart and circulation.

In many EU and ESC member countries, office-based general cardiologists work in isolation or in group practices outside hospitals, and serve a network of general practitioners. They perform general cardiac evaluation and treatment of patients with suspected or established cardiovascular disease using non-invasive methods. Office-based general cardiologists have a pivotal role in the interplay between general practitioners and hospitals with more advanced functions. In small- and medium-sized hospitals, the general cardiologist is the core of the cardiology department. In cardiovascular centres within larger hospitals (referral centres), the general cardiologist may be (but is not necessarily) the coordinator of the activity of general cardiologists and sub-specialists. He or she then has the primary responsibility for the development and application of clinical care pathways. The general cardiologist is a team-worker who interacts closely with sub-specialty cardiologists, other medical specialties, nurses, paramedics, and other healthcare professionals.

Advances in technology call for sub-specialization in many areas of cardiology, especially in those where skills are highly dependent on the number of examinations or interventions performed, such as in cardiovascular X-ray computed tomography, magnetic resonance imaging, interventional cardiology, electrophysiology, and acute cardiovascular care. This natural and unavoidable evolution of the cardiological specialty requires team working between cardiologists with different profiles and with related specialties.

The process for medical decision-making and patient information is guided by the 'four principles' approach to healthcare ethics: autonomy, beneficence, non-maleficence, and justice. Trainees in cardiology need to develop skills in the different roles of a physician. These roles are the physician as a care provider, as a scientist, as a communicator, as a manager, as a collaborator, as a scholar, and as a health advocate.¹⁶ All aspects of the Core Curriculum fit under the umbrella of one or more of these roles. The cardiologist must know the indications, strengths, and limitations of every examination and intervention; such knowledge can be derived from a solid background in research methodology and statistics. Cost-effectiveness is increasingly important and should be a consideration in all medical decisions. Patient safety should be a permanent concern. The cardiologist must be an effective communicator; at all stages of the clinical process it is essential to be able to explain, in layman's terms, the significance of the findings and their implications. Skill is required to manage a medical problem whilst, at the same time, managing the cardiologist's relationship with the patient and relatives with empathy and respect for their socio-economic, ethnical, cultural, and religious background. Skilful communication serves to relieve uncertainty, to support the patient who is facing a poor prognosis or experiences complications or an unsuccessful intervention, and to sustain adherence with lifestyle and pharmacological therapy. Cardiologists often face difficult decisions relating to resuscitation and the implementation of advanced therapies or transfer to the intensive care environment; they must be able to maintain the dialogue with and trust of the patient and relatives in these circumstances, and attempt to anticipate when

they may, or may not, accept a suggestion for conservative therapy or palliative care. In this document, we insist heavily on the physician as a team player. In many clinical settings, the indications for an invasive diagnostic procedure or intervention may be unambiguous, but in other situations there will be differences in opinion, local expertise, and logistics that necessitate a concerted multi-disciplinary approach, derived from assessment by a Heart Team.^{2,3} The creation of a Heart Team, which includes general cardiologists, interventional cardiologists, anaesthetists, cardiac surgeons and other care providers, serves the purpose of a balanced decision-making process. Additional input may be needed from general practitioners and other medical and paramedical care providers. Patients and their relatives play a crucial role and need help in making informed decisions about their treatment. The most valuable advice will, in most instances, be provided to them by way of a consensus decision of the Heart Team.

Cardiologists handle sensitive personal data on their patients. These data should be protected with the utmost confidentiality, in accordance with personal data protection legislation in the European Union.

The general cardiologist may decide, after completion of training, to develop additional knowledge and skills. The areas of specialized experience currently include

- (a) interventional cardiology;
- (b) electrophysiology and device therapy;
- (c) cardiovascular imaging (echocardiography, cardiac X-ray CT, CMR, nuclear and PET scan);
- (d) cardiovascular intensive care;
- (e) advanced heart failure and transplantation;
- (f) cardiac rehabilitation and prevention;
- (g) grown-up congenital heart disease (GUCH).

The additional knowledge and skills may be acquired in part during the training in general cardiology, but full expertise and certification in each of these areas will require additional training, either as part of a focused sub-specialty programme or as CME. The Core Curriculum for the general cardiologist includes a depth of knowledge of the sub-specialties, sufficient to ensure that patients are referred appropriately for more advanced investigations and therapies. The specialized expertise required for these different domains of cardiology is not included in the Core Curriculum.

Assessment of competence is not included in the present document. This does not obviate the importance of regular, structured, and formally documented assessment, which is crucial to implementation of the curriculum. This should include assessments of knowledge (formative and summative), formally observed procedures and practices, (online) log-books and, where available, the use of simulators (which are applicable both to training and assessment).

The training should imbue the cardiologist with the habit of life-long learning and enable them to improve their knowledge of and experience in the practice of cardiology, to adapt to technological innovations, to provide the educational and experiential preparation necessary to underpin progression, where desired, to further sub-specialty training and, above all, to respond to the changing

expectations of society. Throughout the training programme, and afterwards, the cardiologist should apply the best available evidence to deliver optimal patient-centred care, following the principles of evidence-based medicine as developed in the Clinical Practice Guidelines of the ESC.

1.2 General aspects of training in the speciality

Candidates for training should be physicians licensed to practice in the country of training. The trainee must have the necessary linguistic ability to communicate with patients and colleagues in the country of training and later in the country of practice.

It is understood that a common trunk of general professional training should be completed before postgraduate specialist training is undertaken. General training should include the acquisition of extensive knowledge of and exposure to the acute and chronic presentations of a broad range of medical conditions.

Learning objectives should be clearly defined, and are preferred to recommendations based solely on the time spent in a particular department or on the number of procedures performed. The objectives should include *knowledge*, and specific and generic *skills* including communication and appropriate *behaviours* and *attitudes* that will further be reinforced during ongoing training.

The recommended duration of postgraduate education is a minimum of 6 years, to include 2 years of common trunk (internal medicine and/or related specialties) and a minimum of 4 years of full-time and exclusive training in cardiology.

To gain sufficient experience, the trainee should be involved in the management of an appropriate mix and number of in-patients and outpatients, including the following elements:

- participation in the clinical management of in-patients, including the coronary care unit and provision of cardiac consultations for other departments, should constitute a substantial part of the training programme;
- supervised involvement in the management of outpatients, including new and return cases, should be undertaken at least once a week throughout the programme;
- a regular on-call commitment for cardiology (rather than general internal medicine or unselected medical emergencies) throughout the programme;
- at least 2 h a day in structured learning, under the direct supervision of the educational supervisor, which may include:
 - explicit learning: journal clubs, methodology of research and statistics, postgraduate teaching, training in communication skills, exercises in evidence-based medicine, discussion of guidelines for clinical practice;
 - implicit learning: rounds, case-based discussions, supervised acquisition of diagnostic, and therapeutic skills.
- basic, clinical, and/or translational research in cardiovascular medicine should be an inherent part of the cardiovascular training programme. The Core Curriculum insists on the importance of

stimulating trainees to participate in basic or clinical research and to develop a critical and research-oriented approach to clinical practice. When cardiovascular research is performed on a full-time basis or to an extent that prevents sufficient progression of clinical training, adaptation of the total training time must be considered;

- the training programme should be clearly defined for each individual, incorporate a periodic review of their progress, and formal assessment at least once a year.

1.3 Requirements for training institutions and trainers

1.3.1 Requirements for training institutions

- Training institutions should be recognized by a National Training Authority as being competent to provide a complete training programme, either in the same centre or in collaboration with others. It is highly desirable for the trainees to be exposed to other medical specialties throughout their postgraduate education;
- The ideal situation for a training programme is within a comprehensive heart centre where all aspects of cardiovascular disease are managed. However, it can happen that not every aspect of training is accessible at a single site; in these circumstances, rotation through different institutions or sessional attendance in centres providing sub-specialties or technologies that are not widely available, may need to be incorporated into the programme;
- Training institutions should have a library and internet facilities offering access to the current world scientific literature, specifically major international journals relating to cardiology and internal medicine, and should provide the necessary physical infrastructure for training including conference rooms and allocated office space for trainees;
- The training institution alone or as part of a structured and organized collaboration should have the necessary facilities to ensure that trainees can fulfil all aspects of the Core Curriculum with a sufficient number of patients and procedures for developing the required skills:
 - a fully equipped facility for treating outpatients and emergencies;
 - a sufficient number of beds for in-patients;
 - a coronary care unit with at least six beds with electrocardiographic and haemodynamic monitoring, and facilities for anti-bradycardia pacing, cardioversion, and defibrillation. Exposure to more intensive therapy (e.g. assisted ventilation and ultrafiltration) and haemodynamic support devices (intra-aortic balloon pumps, assist devices, and haemofiltration) should be available at some time during the training;
 - equipment should be available for all types of non-invasive diagnostic and therapeutic procedures including X-ray, electrocardiogram (ECG), exercise and pharmacological stress testing, cardiopulmonary exercise testing (CPX), ambulatory ECG monitoring, echocardiography and trans-oesophageal echocardiography (TOE), reading and programming of implanted pacemakers and cardiac defibrillators, CMR imaging, cardiac X-ray computed tomography, and nuclear medicine. The institution must have facilities for invasive cardiology, including diagnostic and therapeutic cardiac catheterization, and electrophysiological studies;

– the programme must incorporate an institution providing cardiac surgery for an optimal daily functioning of the Heart Team.

- The trainee should be provided with the opportunity to participate in basic scientific or clinical research. If basic science research facilities are not available in the training institution, collaboration with centres that offer this option should be made available for the trainee.

1.3.2 Requirements for trainers

Trainers should be recognized by the National Training Authorities and supervision of training should be available at all times.

There should be a minimum number of expert cardiologists in the training institution to ensure training in all areas included in the Core Curriculum.

Ideally the number of trainees should not exceed the number of trainers (full-time equivalent). This number includes trainees in general cardiology, postgraduate trainees in cardiology sub-specialties, residents in internal medicine or related specialties, visiting fellows, and others. Delivery of the curriculum may be facilitated by a structure that includes a Director of Training (National/Regional), a Training Mentor (or educational supervisor), and multiple Clinical Trainers (or clinical supervisors). The training mentor (or someone else involved in the organization of training) should be responsible for organizing the training programme in general cardiology, coordinating external rotations to referral centres, attendance at courses and congresses, and organizing structured learning. It is necessary that both trainee and training mentors are subject to periodic assessment.

1.4 Learning objectives

These are specific statements of intent, which express what the learner will be able to do at the end of the educational intervention. They are framed in terms of trainees' capabilities in specific tasks. Objectives are classified under the headings of knowledge, skills, and behaviours and attitudes. Each objective defines what is to be achieved.

Knowledge: The knowledge base trainees require. The subject matter is defined by the ESC Core Curriculum chapters. This knowledge includes mechanisms of diseases as the rational basis for long-term learning.

Skills: The effective application of knowledge to problem solving, clinical decision-making, and performing procedures, acquired from experience and training.

Behaviours and attitudes: The attitudes that underlie best behaviour in clinical practice that trainees need to develop and demonstrate

Categories and levels of competence

This section of the curriculum describes the different levels of competence expected for skills related to investigations and procedures. These are defined as follows:

Level I: experience of selecting the appropriate diagnostic or therapeutic modality and interpreting results or choosing an appropriate treatment for which the patient should be referred. This level of competency does not include performing a technique, but participation in procedures during training may be valuable;

Technique	Description of competence	Level of competence
ECG	Competent in all aspects	Level III
Long-term ECG methodologies	Competent in all aspects	Level III
Exercise ECG testing	Competent in all aspects	Level III
Cardiopulmonary exercise testing	Able to perform and interpret independently in routine cases	Level II
Ambulatory BP monitoring	Competent in all aspects	Level III
Trans-thoracic echocardiography	Competent in all aspects	Level III
Vascular ultrasound	Able to perform and interpret independently in routine cases	Level II
Trans-oesophageal echocardiography	Able to perform and interpret independently in routine cases	Level II
Stress-echocardiography	Some practical experience but not as an independent operator	Level II
Nuclear studies	Able to interpret the data independently	Level II
Cardiac X-ray computed tomography	Able to interpret the data independently	Level II
Cardiovascular magnetic resonance	Able to interpret the data independently	Level II ^a
Venous and arterial puncture	Competent in all aspects	Level III
Invasive haemodynamics including right heart and pulmonary artery catheterization	Competent in all aspects	Level III
Coronary and LV angiography	Competent in all aspects	Level III
Percutaneous intervention	Having assisted at procedures	Level I
Cardiac surgery	Having assisted at procedures	Level I
Temporary pacemaker implantation	Competent in all aspects	Level III
Pacemaker programming	Competent in all aspects	Level III
ICD/CRT programming	Some practical experience	Level II
Pacemaker implantation	Practical experience in uncomplicated cases	Level II
ICD implantation	Having participated at procedures	Level I
CRT implantation	Having participated at procedures	Level I
Electrophysiological studies	Some practical experience; able to understand electrophysiological tracings	Level II
Electrophysiological interventions	Having participated at procedures	Level I
Electrical cardioversion	Competent in all aspects	Level III
Pericardiocentesis	Competent in all aspects	Level III

^aThis level II for CMR is in accordance with level 1 of the document 'Training and accreditation in cardiovascular magnetic resonance in Europe: a position statement of the working group on cardiovascular magnetic resonance of the European Society of Cardiology'.¹⁷

Level II: level II goes beyond Level I. In addition to Level I requirements, the trainee should acquire practical experience but not as an independent operator. They should have assisted in or performed a particular technique or procedure under the guidance of a trainer. This level also applies to circumstances in which the trainee needs to acquire the skills to perform the technique independently, but only for routine indications in uncomplicated cases;

Level III: level III goes beyond the requirements for Level I and II. The trainee must be able independently to recognize the indication, perform the technique or procedure, interpret the data, and manage the complications.

Level of competence of cardiological skills

The table summarizes the level of competence that the ESC considers desirable for a trainee in general cardiology to achieve; those

sub-specializing in a particular aspect of cardiology will require the highest levels of competence in the relevant techniques, necessitating a longer duration of training. It is appreciated that the organization of cardiac services and the resources for training are not uniform throughout Europe and ESC member states, but the Core Curriculum aspires to an optimal, rather than a minimal, standard. In countries (or centres) that are currently unable to deliver training in all its aspects, the Core Curriculum should be used as a benchmark to promote policies for improvement. Rotation of trainees between different centres can, in most situations, provide an adequate solution.

First-hand exposure and practical experience play an important role in the learning of techniques. In this document we focus on the acquisition of skills rather than on numbers. The number of procedures engaged in by trainees is important but is not in itself a robust measure of competence.

Part 2: The Core Curriculum per Topic

2.1 History taking and clinical examination

Objectives

History taking

To establish a relationship with the patient based on empathy and trust and to obtain a clinical history relevant to cardiovascular disorders, including:

- the patient's spontaneous account of symptoms;
- questions from the cardiologist focused on the presence or absence of possible cardiovascular symptoms;
- the past medical history;
- cardiovascular risk factors and reversible causes for cardiovascular diseases;
- symptoms of any co-morbidities;
- family history (cardiovascular and other diseases);
- current and past drug therapy;
- social history (including patient's socio-economic situation, professional, educational, and religious background).

Clinical examination

It is emphasized that the trainee should complement the subjective findings from the clinical history with the objective findings on clinical examination of the cardiovascular system, to establish a diagnosis and management plan:

- to perform a general examination of the patient searching for manifestations of cardiovascular disease and/or evidence of co-existing illness;
- to examine the heart;
- to examine the vascular arterial and venous systems.

Knowledge

History taking

- Range and meaning of words used by patients to describe their symptoms;
- Several symptoms of cardiovascular disease and features that differentiate them from non-cardiovascular conditions;
- Cardiovascular risk factors derived from the patient's history and the importance of global cardiovascular risk assessment;
- Names, pharmacology, and side-effects of the drugs prescribed to cardiovascular patients;
- Clinical manifestations and treatment of the co-morbidities often associated with cardiovascular disease;
- Clinical manifestations and treatment of inherited cardiovascular diseases and the principles of family counselling.

Clinical examination

- Blood pressure (BP) measurement: principles and limitations of its diagnostic and prognostic values, keeping in mind the high variability of clinic BP;
- Characteristics of the normal and abnormal arterial pulse, heart rate, and rhythm;

- The normal and abnormal precordial impulse;
- Heart auscultation in relation to the cardiac cycle in health and disease;
- Right atrial pressure (jugular venous pressure);
- Palpation and auscultation of arteries. Significance of abnormal arterial pulses and vascular bruits at various sites;
- Ankle–brachial index (ABI) as an indication of advanced peripheral arterial disease;
- The venous system;
- Clinical signs of under-perfusion and fluid retention;
- Features on general examination caused by cardiovascular disease (lungs, liver, skin, and limbs).

Skills

History taking

The ability to:

- analyse the information obtained from a patient's history and integrate it with the clinical examination, in order to develop an overall assessment and to establish a diagnostic and therapeutic plan;
- clarify important clinical information;
- evaluate cardiovascular risk using established risk scores.

Clinical examination

The ability to:

- make and record accurate observations about the clinical state of the patient, with particular emphasis on the cardiovascular system in health and disease;
- perform a thorough clinical (and basic neurological) examination; special emphasis on palpation and auscultation of heart, lungs, and arteries, inspection of venous pulse, evaluation of liver enlargement, ascites, and oedema;
- record the history and findings on clinical examination in a structured electronic or written file.

Behaviours and attitudes

- Consideration for the patient in order to allow sufficient time to describe symptoms in their own words;
- Willingness to document past-history from general practitioners
- Sensitivity in asking direct and open-ended questions;
- Willingness to contribute in collaboration with the general practitioners, to the global rather than solely the cardiovascular care of the patient;
- Empathy and respect for patients' socio-economic, ethnical, cultural, and religious background;
- Examination of patients with due regard for their dignity.

2.2 The electrocardiogram

Objectives

To select, perform, and interpret each of the non-invasive ECG techniques:

- standard 12-lead ECG;
- long-term ambulatory ECG;
- exercise ECG testing;
- cardio-pulmonary exercise testing (CPX)¹⁰.

Knowledge*12-Lead ECG*

- The cellular and molecular mechanisms involved in the electrical activity of the heart;
- The anatomy and physiology of the conduction system;
- The electrical vectors throughout the cardiac cycle;
- The normal ECG and how it derives from electrical vectors;
- Common artefacts and lead reversal ECGs;
- The characteristic appearances of, and explanation for, the ECG in patients with:
 - (a) chamber hypertrophy;
 - (b) ischaemia and infarction;
 - (c) 15- or 18-lead ECGs can be performed with an alternate precordial lead placement to assess posterior- or right-sided disease;
 - (d) conduction disturbances
 - (i) left bundle branch block, right bundle branch block;
 - (ii) hemifascicular block;
 - (iii) other types of intraventricular conduction delay;
 - (iv) AV-block;
 - (e) tachycardias and bradycardias;
 - (f) pre-excitation;
 - (g) chanellopathies
 - (i) QT abnormalities (short QT, long QT);
 - (ii) Brugada ECG pattern;
 - (iii) early repolarization;
 - (h) other repolarization disturbances
 - (i) electrolyte abnormalities;
 - (ii) anti-arrhythmic and other drugs;
 - (iii) hypothermia;
 - (i) pericarditis, pericardial effusion, myocarditis;
 - (j) arrhythmogenic cardiomyopathy;
 - (k) pacemaker, ICD, and CRT devices and their dysfunction.

Long-term ambulatory ECG

- The indications;
- The limitations.

Exercise ECG testing

- The main indications
 - evaluation of ischaemia;
 - evaluation of treatment response;
 - evaluation of functional capacity (CPX);
 - evaluation of inducible arrhythmias;
 - evaluation of non-invasive haemodynamic response to exercise (e.g. chronotropic response, BP response);
- Contraindications;
- Criteria for stopping the test;
- Complications and their management.

Cardiopulmonary exercise testing

- The main indications
 - (a) evaluation of exercise tolerance;
 - (b) differentiation between cardiovascular and pulmonary aetiology of exercise intolerance;

- (c) anaerobic threshold and aerobic capacity, VE/VCO₂ slope;
- (d) evaluation of patients with cardiovascular diseases
 - (i) functional evaluation and prognosis in patients with heart failure;
 - (ii) selection for cardiac transplantation;
 - (iii) monitoring cardiac rehabilitation.

Skills*12-Lead ECG*

The ability to:

- perform and systematically interpret the ECG in the clinical context.

Long-term ambulatory ECG

The ability to:

- perform and interpret ambulatory ECGs.

Exercise ECG testing

The ability to:

- perform and interpret the exercise ECG test in the clinical context;
- manage complications and carry out CPR and advanced cardiac life support (ACLS).

Cardiopulmonary exercise testing

- Perform and interpret CPX in routine cases.

Behaviours and attitudes

- Awareness of the influence of pre-test probability on post-test probability (Bayes' law);
- Encouragement and reassurance to the patient throughout the examination.

2.3 Non-invasive imaging**2.3.1 Non-invasive imaging in general***Objectives*

- To select the appropriate imaging modalities according to the clinical condition:
 - non-invasive imaging in general;
 - echocardiography of heart and vessels;¹³
 - cardiac magnetic resonance (CMR);¹⁷
 - cardiac X-ray computed tomography (CT);
 - nuclear techniques.
- To interpret and integrate the results into individual patient care;
- To perform most TTE and routine TOE echocardiographic examinations independently.

Knowledge

- Use of these modalities to assess cardiac structure and function
 - cardiac chamber size and wall thickness;
 - left ventricular (LV) mass;
 - ventricular and atrial volumes;
 - measurement of LV and right ventricular (RV) systolic function;
 - assessment of LV and RV diastolic function;
 - assessment of valvular stenosis;

- assessment of valvular regurgitation;
- assessment of coronary artery disease, including calcification of coronary arteries (+ calcium score); non-invasive angiogram;
- evaluation of the ischaemic myocardium, including regional wall motion abnormalities, scar, stunning, hibernation, perfusion, and viability;
- myocardial disease;
- pericardial disease;
- cardiac tumours/masses;
- congenital heart disease;
- estimation of shunt size and consequences;
- thoracic and abdominal aortic diseases;
- diseases of the pulmonary circulation;
- the effects of surgical and interventional procedures.
- Use of these modalities to assess vascular anatomy and function
 - carotid and vertebral arteries (cervical arteries);
 - thoracic and abdominal aorta;
 - peripheral arteries;
 - lower limb venous system.
- Principles of stress testing as applied in cardiac imaging, including
 - treadmill and bicycle exercise;
 - vasodilator stress (dipyridamole, adenosine, and related agents);
 - sympathomimetic stress (dobutamine).
- Knowledge of radiation exposure with different imaging techniques and principles of radiation protection.

Skills

The ability to:

- choose the appropriate imaging techniques for specific clinical situations, utilizing a thorough understanding of the Bayesian approach;
- choose the appropriate stress technique for a particular patient;
- interpret results of imaging examinations and extract prognostic information;
- ensure safety through:
 - application of the principles of radiation and magnetic resonance safety;
 - preparation of the patient;
 - prevention, detection, and treatment of contrast-induced nephropathy;
 - use of correct acquisition protocols and technologies to reduce radiation dose.

Behaviours and attitudes

- Selection of imaging techniques, modalities, and protocols in a clinically useful and cost-effective way, avoiding over- and under-utilization of tests and, where applicable, keeping in mind radiation exposure;
- Recognition of strengths and weaknesses of the different non-invasive imaging modalities in specific clinical situations.

2.3.2 Echocardiography

Knowledge

- Techniques:
 - M-mode;
 - two- and three-dimensional (2D and 3D) modes;

- Doppler imaging (blood flow, tissue);
- ultrasound examination of arteries and veins;
- contrast echocardiography;
- trans-oesophageal echocardiography (TOE);
- deformation imaging (speckle-tracking- and Doppler-based strain analysis);
- stress-echo modalities (exercise and/or pharmacological echo).
- Cardiac indications:
 - global left ventricular (LV) and right ventricular (RV) systolic and diastolic function;
 - regional LV function, including ischaemic regional wall motion abnormalities and their implications for the presence of scar, stunning, hibernation, perfusion, and viability;
 - LV mass, scaling for body size, and hypertrophy;
 - cardiac chambers anatomy, size, function;
 - primary and secondary cardiomyopathies (dilated, hypertrophic, restrictive, arrhythmogenic);
 - valvular morphology and function, including stenosis and regurgitation, multivalvular diseases;
 - valve repair, valve prostheses, percutaneous valve implantation;
 - endocarditis;
 - pericardial disease (including cardiac tamponade);
 - cardiac masses (tumours, thrombi, vegetations, foreign bodies);
 - congenital heart disease before and after surgical correction;
 - shunt lesions;
 - pulmonary hypertension;
 - non-invasive haemodynamics, including cardiac output, LV filling pressures, pulmonary artery pressure, and right atrial pressures;
 - liver congestion and venous flow, respirophasic changes of the vena cava;
 - pathology to anticipate and to screen for in emergency echocardiography (see chapter 2.27).
- Vascular indications:
 - carotid intima-media thickness and plaques;
 - stenosis of the carotid, vertebral, abdominal, and lower limb arteries;
 - thoracic and abdominal aortic diseases;
 - venous insufficiency;
 - anatomy of the pulmonary veins.

Skills

The ability to perform and interpret:

- trans-thoracic echocardiography;
- vascular ultrasound;
- trans-oesophageal echocardiography;
- stress-echocardiography.

Behaviours and attitudes

- Integration of echocardiography with history taking, clinical examination, ECG (at rest and during exercise) as the baseline evaluation of the cardiac patient by the general cardiologist;
- Recognition of the strengths and weaknesses of echocardiography in a clinical situation, and in relation to other imaging modalities. The general cardiologist should be willing to refer to other imaging modalities when necessary;

- Interactive co-operation with sonographers and paramedical staff for acquisition of the data.

2.3.3 Cardiac magnetic resonance

Knowledge

- Techniques
 - (a) basic CMR physics;
 - (b) image quality and artefacts;
 - (c) CMR safety and safety of medical devices in CMR;
 - (d) CMR contrast agents: indications and safety;
 - (e) CMR methodology
 - (i) cardiac anatomy (including dark and bright blood techniques);
 - (ii) cardiac function (including cine and myocardial tagging methods);
 - (iii) tissue characterization (including contrast-enhanced techniques);
 - (iv) CMR stress imaging (myocardial perfusion and dobutamine stress CMR);
 - (v) blood flow assessment with flow-velocity encoded CMR;
 - (vi) MR angiography.
- Indications
 - (a) ischaemic heart disease (IHD);
 - (b) diagnosis and management of chronic IHD;
 - (c) ischaemia testing with myocardial perfusion and dobutamine stress CMR;
 - (d) viability assessment with late-gadolinium-enhanced (LGE) CMR;
 - (e) coronary imaging;
 - (f) diagnosis and management of acute IHD;
 - (g) infarct size and area at risk in acute coronary syndromes (ACS) with late-gadolinium enhancement and T_2 -weighted CMR;
 - (h) LV and RV function post-myocardial infarction;
 - (i) microvascular obstruction and intramyocardial haemorrhage;
 - (j) myocardial disease
 - (i) diagnosis and prognostication in inherited cardiomyopathies;
 - (ii) diagnosis and prognostication in myocarditis;
 - (iii) cardiac involvement in systemic disease/secondary cardiomyopathies;
 - (iv) diagnosis and prognostication in acute and chronic heart failure;
 - (v) assessment of transplant cardiomyopathy;
 - (k) pericardial disease
 - (i) normal anatomy and diagnosis of pericardial disease;
 - (ii) assessment of functional effects of pericardial disease;
 - (l) vascular disease
 - (i) morphology and pathology of the thoracic and abdominal aorta, including aneurysm and dissection;
 - (ii) morphology and pathology of the pulmonary vessels;
 - (iii) morphology and pathology of the cervical arteries and of the peripheral circulation;
 - (iv) morphology and pathology of the systemic veins;

- (m) valvular disease
 - (i) assessment of valve morphology;
 - (ii) quantification of valve stenosis;
 - (iii) quantification of valve regurgitation;
 - (iv) LV and RV dimensions and function;
- (n) cardiac and pericardial masses/tumours;
- (o) congenital heart disease
 - (i) diagnosis and long-term follow-up;
 - (ii) quantification of shunt volumes;
- (p) incidental (non-cardiovascular) findings.

Skills

The ability to:

- select appropriate indications for and avoid contraindications to CMR examinations;
- supervise cardiovascular stress safely using pharmacological techniques;
- display and interpret CMR images in the clinical context (level II competence).

Behaviours and attitudes

- Continuing curiosity and willingness to refer for the rapidly evolving indications in the field of CMR;
- Cooperation with radiologists, paramedical and other medical professionals.

2.3.4 Cardiac X-ray computed tomography

Knowledge

- Techniques
 - (a) test bolus acquisition and bolus chasing;
 - (b) prospective ECG-triggered axial, and retrospectively ECG-gated spiral scan modes;
 - (c) cardiac X-ray CT without contrast enhancement
 - (i) coronary calcium score;
 - (d) cardiac X-ray CT with contrast enhancement
 - (i) coronary artery disease;
 - (ii) cardiac morphology;
 - (e) angiography of the great arteries and veins.
- Indications
 - (a) coronary artery disease
 - (i) coronary calcium score;
 - (ii) CT angiography of the coronary arteries to assess degree of coronary stenosis;
 - (iii) bypass graft disease;
 - (iv) visualization of plaque characteristics;
 - (b) coronary anomalies;
 - (c) cardiac (non-coronary) pathology: congenital, traumatic, degenerative, atherosclerotic (infarcts/LV aneurysms, etc.), masses;
 - (d) interventional guidance: e.g. transcatheter valve implantation, pulmonary vein isolation;
 - (e) ventricular function;
 - (f) prosthetic heart valve dysfunction
 - (i) quantification of opening and closing angles;
 - (ii) visualization of thrombus and pannus;

- (g) endocarditis of native heart valves and prosthetic heart valves
 - (i) visualization of valvular vegetations;
 - (ii) assessment of annular abscesses and mycotic aneurysms and relationship to coronary arteries;
- (h) congenital heart disease
 - (i) anatomy;
 - (ii) quantification of ventricular volumes and function;
- (i) pericardial diseases
 - (i) including pericardial calcification;
- (j) diseases of the great arteries and great veins (congenital anomalies, aortic aneurysms, false aneurysms, aortic dissection, periaortic abscesses, aortic arch abnormalities);
- (k) diseases of the cervical arteries and of the peripheral arteries.

Skills

The ability to:

- select appropriate indications for and avoid contraindications to cardiac X-ray CT;
- display and interpret cardiac X-ray CT images in the clinical context.

Behaviours and attitudes

- Cooperation with radiologists, paramedical, and other medical professionals;
- Awareness of the side-effects of contrast media and recognition of the risks of radiation to patient and personnel;
- Continuing curiosity and willingness to refer for the rapidly evolving indications in the field of X-ray computer tomography.

2.3.5 Nuclear techniques

Knowledge

- Techniques
 - (a) basic principles of radionuclide imaging as applied to the cardiovascular system, including radio-isotopes, radiopharmaceuticals, gamma cameras, image acquisition, reconstruction, display, and interpretation;
 - (b) single-photon emission computed tomography perfusion scintigraphy (SPECT);
 - (c) gated SPECT (perfusion and LV function)
 - (i) tracers: ^{201}Tl , $^{99\text{m}}\text{Tc}$ -sestamibi, or $^{99\text{m}}\text{Tc}$ -tetrofosmin;
 - (ii) modalities:
 - rest imaging;
 - stress imaging (exercise and pharmacological stress with vasodilators and sympathomimetic agents);
 - 2-day and 1-day protocols;
 - (d) positron emission tomography (PET): myocardial perfusion, glucose metabolism, and inflammation imaging;
 - (e) hybrid techniques (PET-CT and SPECT-CT) for attenuation-corrected imaging and for combined anatomical and functional imaging;
 - (f) radionuclide ventriculography using equilibrium planar and SPECT imaging, and first-pass planar, phase, and amplitude imaging of regional function;
 - (g) imaging of sympathetic innervation;

- (h) imaging of pulmonary embolism, quantification of pulmonary perfusion and right-to-left shunting;
 - (i) labelled leucocyte imaging for myocardial abscesses and infection;
 - (j) imaging of myocardial sarcoidosis.
- Indications
 - (a) diagnosis of chest pain syndromes;
 - (b) management of known and suspected coronary artery disease including detection, localization, and quantification of myocardial ischaemia and scar;
 - (c) assessment of prognosis in stable coronary artery disease, in ACS and before non-cardiac surgery;
 - (d) assessment of LV dysfunction and heart failure, including global and regional LV function, abnormalities of myocardial motion and thickening, viability, stunning, hibernation, and innervation;
 - (e) monitoring of LV function before and during cardiotoxic chemotherapy;
 - (f) detection and quantification of left-to-right and right-to-left shunting;
 - (g) detection of cardiac infection and inflammation.

Skills

The ability to:

- select appropriate indications for and avoid contraindications to nuclear cardiology techniques;
- supervise cardiovascular stress testing using dynamic exercise and pharmacological techniques;
- handle unsealed radiopharmaceutical sources in a manner that is safe for oneself, patients and staff, and;
- display and interpret nuclear cardiology images (Level II competence).

Behaviours and attitudes

- Cooperation with referring colleagues and with nursing staff, nuclear medicine physicians and technical and physics professionals;
- Awareness of the side-effects of ionizing agents and recognition of the risks of radiation to patient and personnel.

2.4 Invasive imaging: cardiac catheterization and angiography

Objectives

- To perform and analyse:
 - coronary and LV angiography;
 - cardiac catheterization and haemodynamics.
- To obtain fully informed patient consent for the procedure.

Knowledge

- Principles of fluoroscopic imaging, radiation physics, exposure, and safety regulations;
- Nephrotoxic effects of contrast agents, their prevention, and management;
- Catheterization laboratory equipment (physiological monitoring, transducers, blood gas analysers, power injector);

- Radiological anatomy of the heart, aorta, large vessels, and coronary arteries, as well as that of the femoral, radial, and brachial arteries used for vascular access during catheterization;
- Collection of haemodynamic and oximetric data, and how to use the measurements to calculate cardiac output, vascular resistances, valve areas, and shunts;
- Interpretation of pressure waveforms, haemodynamic and oximetric data;
- Techniques and sites of vascular access;
- Type of catheters used in cardiac catheterization and coronary angiography;
- Trans-septal cardiac catheterization;
- Basic principles and indications for intracoronary ultrasound (intravascular ultrasound, IVUS), Doppler, coronary artery pressure measurements (FFR), and optical coherence tomography;
- Complications of cardiac catheterization and angiography and their management.

Skills

The ability to:

- optimize use of the equipment to minimize exposure to radiation in order to protect the patient and the catheterization team, and to minimize the use of nephrotoxic contrast agents;
- obtain arterial (femoral, radial, brachial) and venous access and achieve haemostasis after catheterization;
- carry out left heart catheterization including coronary angiography, ventriculography, aortography, and angiography of coronary bypass grafts, including mammary artery grafts;
- carry out right heart catheterization in the catheterization laboratory and at the bedside, and measure cardiac output, intravascular pressure, and oxygen saturation;
- manage life-threatening arrhythmias and other emergencies in the catheter laboratory;
- assess normal and pathological coronary angiograms, ventriculograms, aortograms, and pulmonary angiograms;
- interpret haemodynamic and oximetric data;
- use adjunctive pharmacological therapy safely and when appropriate.

Behaviours and attitudes

- Assumption of responsibility for the appropriate ordering and performance of invasive tests, while carefully balancing the risks and benefits of these procedures. This implies avoidance of a low threshold to proceed to invasive testing in low probability cases;
- Cooperation with members of the Heart Team, nurses, technicians, and other medical professionals;
- A consistent analytical approach to selecting the appropriate treatment modality (medical, percutaneous, or surgical) based on the clinical context as well as the data generated by cardiac catheterization;
- Awareness of the side-effects of contrast media and recognition of the risks of radiation to patient and personnel.

2.5 Genetics

Objectives

- To assess and manage patients with inherited or familial cardiovascular disease;
- To integrate genetics and epigenetics into the global evaluation of risk in common cardiovascular disease.

Knowledge

- Integration of genetic knowledge in the evaluation of global risk and common cardiovascular diseases;
- Incidence and prevalence of inherited cardiovascular disorders;
- Principles of
 - Mendelian monogenic human diseases: autosomal dominant, autosomal recessive and X-linked;
 - mitochondrial patterns of inheritance;
 - polygenic cardiovascular diseases.
- the major monogenic cardiovascular diseases, such as
 - cardiomyopathies;
 - familial aortopathies;
 - familial arrhythmias;
 - trisomies, in particular trisomy 21;
 - familial dyslipidaemias.

Skills

The ability to:

- evaluate relevant family history and construct a family pedigree;
- counsel index cases and family members at risk on the probability of being affected by a genetic cardiovascular disorder;
- recognize problems with pedigree interpretation such as incomplete penetrance, variable expressivity, and age-related patterns of expressivity;
- manage the uncertainties associated with genetic testing;
- direct patients and families when appropriate to major centres with a specialized interest in their particular disorder.

Behaviours and attitudes

- Cooperation with clinical geneticists and cardiologists specialized in inherited heart diseases;
- A systematic approach to a family with a potentially inherited cardiovascular disease;
- Adoption of appropriate counselling skills to explain, educate, and inform patients fully of the nature of their disease;
- Commitment to improving the recognition and management of familial cardiovascular disease.

2.6 Clinical pharmacology

Objectives

- To master the theory and practice of pharmacological treatment of cardiovascular disorders.

Knowledge

- Classification, mode of action, and dosage of cardiovascular drugs with emphasis on
 - anti-arrhythmic drugs (including class I–IV);

- anticoagulants, antiplatelet drugs, and fibrinolytics;
- beta- and alpha-adrenergic receptor blockers;
- calcium antagonists;
- diuretics;
- inhibitors of the renin–angiotensin–aldosterone system;
- inotropic drugs;
- lipid-lowering drugs;
- other anti-ischaemic drugs (nitrates, potassium channel blockers, haemodynamically neutral antianginal agents);
- sinus node inhibitors;
- vasodilators.
- Pharmacokinetics, pharmacodynamics, pharmacogenetics, indications, contraindications, interactions, adverse effects, and toxicity of cardiovascular drugs;
- Individually tailored choice of drug or combination of drugs according to the patient's age, profile, co-morbidities, genetic background, and ethnicity;
- Cardiovascular side-effects of non-cardiovascular drugs;
- Interpretation of diagnostic tests to assess drug efficacy and safety (laboratory tests, ECG, haemodynamic monitoring, and echo);
- Methodology of research and statistics;
- Evidence-based medicine as the basis for pharmacotherapy.

Skills

The ability to:

- take a full and accurate history of a patient's medication regimen, including over the counter medicines and alternative remedies;
- assess the risks and benefits of prescribing an individualized drug treatment regimen for a given cardiovascular condition;
- monitor the desired effects and side-effects of a patient's drug therapy and make appropriate modifications to the treatment regimen;
- prevent, recognize, and manage possible drug interactions (including treatments of concomitant diseases);
- evaluate the design and results of published clinical trials.

Behaviours and attitudes

- Communication with hospital and community pharmacists as equal partners in healthcare;
- Incorporation of the principles of evidence-based therapy and current guidelines into clinical pharmacology;
- Communication with patients and their family members to improve treatment compliance and to ensure early recognition of possible adverse effects;
- Consideration of the cost-effectiveness and feasibility of the prescribed treatment regimen.

2.7 Cardiovascular prevention

2.7.1 Cardiovascular risk factors, assessment, and management

Objectives¹⁴

- To assess and manage patients with risk factors for cardiovascular disease;
- To understand the mode of action of different prevention methods;

- To describe cardiovascular disease and risk factors in the local community;
- To contribute to the global efforts in reducing cardiovascular morbidity and mortality by communicating the prevention message to the public;
- To approach prevention in a holistic way, understanding the potentiation of cardiovascular risk by clustering of risk factors.

Hypertension¹⁸

See Chapter 2.7.2.

Dyslipidaemia¹⁹

- To diagnose and treat different forms of dyslipidaemia;
- To assess cardiac and extra-cardiac complications of dyslipidaemia.

Diabetes²⁰

- To diagnose diabetes type I and II and its cardiovascular complications;
- To have a knowledge of diabetes treatment.

Lifestyle. Hard return lifestyle should be given the same weight as major risk factors:

- To be aware of the importance of lifestyle (smoking, diet, and exercise) in cardiovascular disease and its prevention;
- To implement methods to correct unhealthy lifestyles.

Knowledge

- Epidemiology of cardiovascular disease in the local community: incidence, prevalence, survival;
- Risk factors in the local community;
- Risk assessment in primary prevention: multifactorial risk interaction and use of risk scoring charts;
- The impact of lifestyle on people at risk of, and patients with, cardiovascular disease;
- The potential of lifestyle changes to prevent and ameliorate cardiovascular disease: diet and nutrition, toxic habits (smoking, alcohol and others), physical activity;
- Emerging risk factors (social, economic, stress, depression, and personality type);
- Treatment/prevention strategies for major risk factors and changes in lifestyle, including corresponding pharmacologic therapies;
- The comprehensive approach required for multiple risk factors;
- Patient compliance.

Hypertension

See Chapter 2.7.2.

Dyslipidaemia

- Epidemiology, aetiology, and pathophysiology of dyslipidaemia;
- Complications of dyslipidaemia;
- Diagnosis and assessment of dyslipidaemia;
- Management of dyslipidaemia, including pharmacologic and non-pharmacologic therapies;
- Detection and management of side-effects of lipid-lowering agents;
- Management of dyslipidaemia in patients with reduced tolerance to lipid-lowering agents.

Diabetes mellitus

- Epidemiology, aetiology, and pathophysiology of diabetes;
- Consequences of diabetes;
- Diagnosis and assessment of diabetes: clinical symptoms and laboratory tests;
- Basic management of diabetes, including pharmacological and non-pharmacological therapies;
- Appreciation of the continuum from impaired glucose metabolism to overt diabetes that ultimately may become insulin requiring.

Lifestyle.

- Smoking:
 - risk associated with smoking;
 - benefits associated with stopping smoking;
 - treatment options for smoking cessation, including drugs.
- Diet:
 - the effect of different types of diet on metabolic profile and clinical outcomes;
 - components of diet associated with a higher rate of atherosclerosis and cardiovascular disease;
 - protective components of diet.
- Exercise:
 - risks associated with a sedentary lifestyle;
 - benefits associated with exercise;
 - evaluation of physical activity;
 - physical activity regimens for individuals in primary and secondary prevention.

Skills

The ability to:

- obtain a relevant history and perform an appropriate clinical examination;
- evaluate cardiovascular risk and assess global cardiovascular risk at the individual level (including HeartSCORE²¹);
- evaluate cardiovascular risk at population level (mortality, morbidity, disability);
- evaluate the benefit of prevention at individual and population levels;
- manage risk factors appropriately, including pharmacological and non-pharmacological therapies;
- communicate their importance to patients, their families, and the wider community, including smoking cessation, diet, and exercise;
- communicate the importance of patient compliance and behaviour;
- motivate patients and families to change lifestyles and be compliant with prescriptions/recommendations;
- monitor patient compliance and behaviour;
- evaluate the benefit of risk factor intervention for the individual patient.

Behaviours and attitudes

- Non-judgemental attitude to patients regarding their lifestyle (e.g. smoking, diet, etc.);
- Exemplify appropriate lifestyle in personal behaviour;

- Team working with other physicians, including general practitioners, diabetologists, nephrologists, and elderly care physicians for the management of specific risk factors;
- Team working with all professionals with a role in primary and secondary prevention (nurses, dieticians, teachers, and politicians).

2.7.2 Arterial hypertension*Objectives*¹⁸

- To identify, assess, and manage patients with elevated blood pressure (BP);
- To integrate arterial hypertension in the evaluation of global cardiovascular risk;
- To identify arterial hypertension as a risk factor for ischaemic heart disease, heart failure, cerebrovascular disease, peripheral artery disease renal failure, atrial fibrillation, and cognitive dysfunction.

Knowledge

- Definition and classification of hypertension;
- Pathophysiology of hypertension: contribution of cardiac output, peripheral artery resistance, and age-related stiffening of the great arteries in the genesis of primary hypertension;
- Central BP and its relation to brachial BP;
- Aetiology and pathophysiology of secondary hypertension (renovascular, renal, hormonal, oestrogen induced, and other causes);
- Interaction between BP regulation and sleep apnoea;
- White-coat hypertension, masked hypertension and implications for measurement of BP and therapeutic decision-making;
- Factors influencing prognosis of hypertension;
- Target organ damage and complications of hypertension for the brain, the kidneys, and the great arteries;
- Lifestyle measures for prevention and treatment of hypertension;
- Pharmacological properties, indications and side-effects of the various classes of antihypertensive drugs;
- Individually tailored choice of antihypertensive drug or combination of drugs according to the patient's age, profile, co-morbidities, genetic background, and ethnicity;
- Interventional techniques for BP control (e.g. renal artery stenosis dilatation, renal artery denervation);
- Targets for BP lowering;
- Definition and management of refractory hypertension;
- Definition and management of malignant hypertension.

Skills

The ability to:

- measure and interpret BP obtained with manual and automatic office devices and ambulatory and home BP monitors;
- evaluate a patient with elevated BP, including comprehensive blood testing, screening for diabetes, the electrocardiogram, echocardiography and vascular ultrasound, central BP assessment, renal function, proteinuria and microalbuminuria, ABI, and fundoscopy;
- manage elevated BP non-pharmacologically and pharmacologically;
- reduce global cardiovascular risk in patients with hypertension, including the use of pharmacological therapy;

- manage hypertensive emergencies.

Behaviours and attitudes

- Team working with general practitioners and other medical specialists in the management of patients with hypertension; in particular, elderly patients, diabetes patients, patients with chronic kidney disease, and patients with cerebrovascular disease;
- Appreciation of the systemic nature of hypertension and its consequences for various vascular beds;
- Awareness of hypertension as major risk factor for cardiovascular diseases;
- Appreciation of and safeguarding against the potential for both under-treatment and over-treatment of patients with high BP;
- Motivation of the patient to maintain long-term compliance with antihypertensive therapy;
- Active participation in hypertension prevention, detection, and treatment programmes in the community.

2.8 Acute coronary syndromes

Objectives^{2,8,9,15} (see also Chapter 27: Acute cardiovascular care)

- To perform specialist assessment and treatment of patients with ACS including
 - STE-ACS (ST-segment elevation ACS) or STEMI (ST-segment elevation myocardial infarction);⁹
 - NSTEMI-ACS (non-ST-segment elevation ACS) or NSTEMI (non-ST-segment elevation myocardial infarction);⁸
 - unstable angina.

Knowledge

- Diagnostic criteria for ACS and myocardial infarction;
- Classification of myocardial infarction¹⁵;
- Pathophysiology of ACS, including plaque rupture or erosion, thrombosis, vasospasm, immunity (innate and acquired) and cell necrosis. Impact at the level of epicardial coronary arteries, smaller arteries, the micro-circulation, and the myocardium;
- Knowledge of non-atherosclerotic causes of ACS (e.g. variant angina, coronary dissection, takotsubo cardiomyopathy, coronary embolism);
- Events that precipitate ACS;
- Dominant clinical features of ACS;
- Diagnostic process in patients with chest pain with suspicion of unstable angina, NSTEMI-ACS or STE-ACS;
- Diagnostic techniques including ECG, troponin and other biomarkers, echocardiography and other imaging modalities;
- Risk scores in patients with ACS;
- Monitoring (ECG and hemodynamic monitoring);
- Treatment of ACS: pre- and early hospital pharmacological therapy. Indications for interventional therapy based on clinical judgement and available risk scores;
- Properties, effects, indications, contraindications, and secondary effects of analgesics, anti-ischaemic drugs, anticoagulants, fibrinolytics, platelet inhibitors, statins, and other drugs for secondary prevention - use and complications of antithrombotic drugs in combination;
- PCI techniques, balloon techniques, stents;
- Role and treatment of co-morbidities;

- Early and late complications of ACS and their treatment.

Skills

The ability to:

- take a relevant history and perform an appropriate clinical examination;
- appreciate the role of risk factors, the clinical characteristics of coronary occlusion, and the subsequent clinical course;
- repeated biomarkers measurements and their kinetics interpretation;
- interpret ECG and imaging techniques to detect and localize ischaemia and/or infarction;
- use algorithms for diagnosis;
- obtain informed consent for invasive procedures;
- monitor patients with ACS;
- prescribe appropriate pharmacological treatment including analgesics, anti-ischaemic drugs, anticoagulants, fibrinolytics, platelet inhibitors, statins, and other drugs for secondary prevention;
- use a risk score to evaluate prognosis and select patients for early or delayed coronary angiography and revascularization;
- diagnose and treat complications during the acute phase of ACS.

Behaviours and attitudes

- Team working with other specialists, including medics/paramedics in ambulances and mobile coronary care units, nurses, and physicians in the emergency department, intensive care unit or cardiac monitoring unit and catheterization laboratory. This includes the Heart Team (cardiologists, interventional cardiologists, anaesthetists, and cardiac surgeons) for decisions on urgent revascularization;
- Appreciation of the urgency of making decisions on patients with ACS, from the time of onset of symptoms until therapy is administered with special emphasis on minimizing time to reperfusion;
- Appreciation of the distress that unexpected and serious illness causes both to patients and to their relatives;
- Willingness to play an appropriate role in a hospital network for optimal management of patients presenting with ACS, and transferring patients quickly;
- Willingness to contribute to improving public awareness of the significance of chest pain and to encourage early presentation.

2.9 Chronic ischaemic heart disease

Objectives^{2,22}

- To perform specialist assessment and treatment of patients with chronic IHD;
- To interpret the results of diagnostic procedures to evaluate ischaemia, ventricular function and complications of chronic IHD; and
- To select and apply appropriate therapies for ischemia, secondary prevention and complications of chronic IHD.

Knowledge

- Epidemiology of chronic IHD and its risk factors;
- Molecular and cellular biology of IHD;
- Coronary physiology;

- Pathophysiology of ischaemia: plaque formation, clotting, innate and acquired immunological mechanisms, vasospasm;
- Effects of myocardial ischaemia on the myocardium, including stunning, hibernation, and viability;
- Events that precipitate an angina attack;
- Prognosis of chronic IHD;
- Clinical assessment of known or suspected chronic IHD, including differential diagnosis of chest pain and other symptoms and signs. Non-invasive test interpretation based on Bayes' law;
- Indications for, and information derived from, diagnostic procedures including ECG, stress test in its different modalities (with or without imaging, exercise, and stress drugs) and coronary angiography;
- Exercise physiology;
- Management of chronic IHD, including lifestyle measures and pharmacological management;
- Indications for coronary revascularization including PCI, stenting, and CABG;²
- Participants in, and role of, the Heart Team;
- Knowledge of alternative interventions for chronic refractory angina (e.g. external counterpulsation, spinal denervation, spinal cord stimulation).

Skills

The ability to:

- take a relevant history and perform an appropriate clinical examination;
- select, use, and interpret non-invasive and invasive diagnostic tools for the evaluation of ischaemia, viability, LV structure and function, and coronary anatomy;
- interpret the ECG to detect ischaemia and identify arrhythmias;
- manage life-threatening arrhythmias, ischaemia, or other emergency situations during diagnostic tests;
- risk-stratify individual patients and select an appropriate management strategy;
- identify and treat risk factors for chronic IHD; and
- use appropriate therapies for secondary prevention and treatment of ischaemia, and select patients for revascularization.

Behaviours and attitudes

- Commitment to working with the Heart Team (interventional cardiologists, anaesthetists, and cardiac surgeons) and, where appropriate, with input from general practitioners, elderly care physicians, and intensivists to reach a decision on revascularization;
- In the absence of on-site cardiac surgery, a consistent approach to application of agreed evidence-based protocols, and willingness to collaborate with off-site expert interventional cardiologists and cardiac surgeons.

2.10 Myocardial diseases

Objectives

- To perform a comprehensive assessment and treatment of patients with cardiomyopathy and myocarditis.

Knowledge

Cardiomyopathy

- Epidemiology and classification of dilated, hypertrophic,²³ restrictive, arrhythmogenic, and unclassified cardiomyopathies;
- Pathophysiology including genetics, diseases causing cardiomyopathies, clinical features, and diagnostic criteria of cardiomyopathies;
- Medical and invasive (surgical, electrophysiological, and interventional) management of cardiomyopathies: indications, contraindications, and possible adverse effects;
- Prognostic factors.

Myocarditis

- Myocarditis as an inflammatory disease, its causes, and its consecutive phases (acute, sub-acute, chronic);
- Clinical features, imaging techniques (in particular CMR), pathology, and diagnostic criteria for infective and non-infective myocarditis;
- Treatment of patients with myocarditis and its complications.

Skills

The ability to:

- take a relevant history, family history, and perform an appropriate clinical examination;
- interpret diagnostic data (ECG, ambulatory ECG, echo, exercise testing, chest X-ray, cardiac catheterization, coronary angiography, magnetic resonance and radionuclide imaging, endomyocardial biopsy, genetic report);
- select appropriate treatment and support modalities (medical, interventional, surgical, ICD/CRT, assist devices, balloon pumping, or other treatment);
- assess individual prognosis in relation to the need for transplantation;
- evaluate patients for endomyocardial biopsy recognizing the diagnostic yield and potential risk of the procedure.²⁴

Behaviours and attitudes

- Alertness to the possibility of infiltrative cardiomyopathy in the presence of unexplained hypertrophy or heart failure;
- Cooperation with medical professionals in other specialties (immunology, bacteriology, genetics, cardiac surgery, interventional cardiology, and imaging) for timely differential diagnosis of myocardial disease and further treatment;
- Sensitivity in counselling patients with cardiomyopathies and their relatives about the risks of transmission and the value and limitations of genetic testing and phenotypic screening.

2.11 Pericardial diseases

Objectives²⁵

- To perform specialist assessment and treatment of patients with pericardial diseases.

Knowledge

- Classification and definition:
 - acute pericarditis;

- relapsing pericarditis;
- chronic pericarditis;
- pericardial effusion and cardiac tamponade;
- constrictive and effusive-constrictive pericarditis.
- Epidemiology, pathophysiology, and aetiology of pericarditis, including infective, inflammatory, and neoplastic disorders;
- Relevant investigations: non-invasive and invasive, including interpretation of laboratory findings;
- Differential diagnosis of constrictive pericarditis from restrictive cardiomyopathy;
- Indications for pericardiocentesis;
- Drug therapy for controlling pericardial inflammation;
- Management of pericarditis and its complications;
- The transient nature of constrictive physiology in some cases.

Skills

The ability to:

- take a relevant history and perform an appropriate clinical examination;
- recognize the ECG abnormalities in acute pericarditis;
- use and interpret echocardiography as the gold standard for initial diagnosis and follow-up;
- select and use additional non-invasive imaging modalities (CMR, X-ray CT, PET) to diagnose pericardial disease;
- perform and interpret invasive pressure measurements to diagnose pericardial disease;
- differentiate pericarditis from myocardial ischaemia;
- perform pericardiocentesis.

Behaviours and attitudes

- Alertness to pericardial diseases within the differential diagnosis of a patient presenting with cardiovascular symptoms and signs;
- Awareness and adoption of the different diagnostic and therapeutic strategies required for each individual case;
- Team working with intensivists, anaesthetists, radiologists, cardiac surgeons, and oncologists.

2.12 Oncology and the heart

Objectives^{26,27}

- To develop knowledge of the manifestations of primary, benign and malignant, and metastatic cardiac tumours;
- To evaluate cardiovascular effects of malignancies and cancer therapies (chemotherapy, radiotherapy, and cancer surgery);
- To participate in the management of patients with tumours involving the heart and with cardiovascular complications associated with the treatment of non-cardiac malignancies.

Knowledge

- Symptoms and signs of cardiac tumours, including systemic and embolic manifestations;
- Classification, diagnosis, and therapy of primary and metastatic cardiac tumours;
- Effects of tumours on coagulation and the occurrence of thromboembolism;

- Obstruction to blood flow induced by proliferative processes (e.g. vena cava syndrome, atrial myxoma, pulmonary artery compression);
- Effects of thoracic radiotherapy on the pericardium, myocardium, conducting system, and coronary arteries;
- Cardiac toxicity associated with cancer therapy: e.g. anthracyclines, trastuzumab, and protein kinase targeted therapeutics;
- Other adverse effects of chemotherapeutic drugs: myocardial ischaemia; thrombosis, and embolism; altered BP; rhythm and conduction disturbances: bradycardia and heart block, tachycardia, arrhythmias;
- Complications of permanent venous access devices;
- Strategies for preventing adverse effects of chemotherapeutic drugs (e.g. statins).

Skills

The ability to:

- use appropriate imaging modalities for diagnosing primary and metastatic tumours and for differentiating tumours from non-neoplastic cardiac masses such as thrombi or vegetations, or aberrant variants of normal structures;
- evaluate the cardiovascular system of patients prior to cancer therapy;
- evaluate the cardiovascular system of patients during and after cancer therapy;
- follow-up and treat oncological patients with cardiovascular complications.

Behaviours and attitudes

- Team working with general practitioners, oncologists, oncological nurses, radiologists, and surgeons;
- Willingness to refer the oncological patient for invasive cardiac evaluation and cardiac biopsy when indicated;
- Empathic and supportive approach towards the psychologically vulnerable oncological patient.

2.13 Congenital heart disease in adult patients

Objectives²⁸

- To evaluate and manage adolescent and adult patients with simple congenital heart defects (grown-up congenital heart disease, GUCH) including those who have undergone cardiac surgery;
- To recognize complex conditions which require referral to a specialist GUCH centre;
- To monitor complex patients in collaboration with a specialist GUCH centre;
- To assess and provide immediate management of emergencies in patients with congenital heart disease.

Knowledge

- Physiology of the foetal and transitional circulations;
- Aetiology of congenital heart disease, including the developmental anatomy of the heart and vasculature;
- Commonly associated genetic syndromes;

- Anatomy of the heart, veins, and great vessels; their major congenital malformations and the principles of nomenclature;
- Pathophysiology, natural history, and complications of:
 - valve and outflow tract lesions;
 - septal defects;
 - patent ductus arteriosus;
 - Eisenmenger syndrome;
 - coarctation of the aorta;
 - Ebsteins's anomaly;
 - aortic and pulmonary artery malformations;
 - venous anomalies;
 - transposition of the great arteries (complete and congenitally corrected);
 - tetralogy of Fallot;
 - functionally univentricular hearts and the Fontan circulation;
 - congenital malformations of coronary arteries;
 - cyanotic congenital heart disease and secondary erythrocytosis;
 - pulmonary hypertension in congenital heart disease.
- Arrhythmias and conduction disturbances;
- Pathophysiology, natural history, and complications of palliative and corrective surgery and interventions;
- Physical signs of congenital heart disease and its complications
- Diagnostic techniques;
- Principles of medical, interventional, and surgical management;
- Prevention of infective endocarditis (IE);
- Hazards of pregnancy, contraception, intercurrent illness, and non-cardiac surgery in patients with congenital heart disease.

Skills

The ability to:

- take a relevant history and perform an appropriate clinical examination;
- select imaging techniques and, where appropriate, invasive procedures for diagnosis;
- provide monitoring and follow-up, where appropriate in collaboration with a specialist GUCH centre, and lifestyle advice;
- manage the patient with pulmonary hypertension and with secondary erythrocytosis.

Behaviours and attitudes

- Acceptance of the role of GUCH specialist teams in the management of patients with complex malformations and complications;
- Appreciation of the importance of long-term surveillance of patients with congenital heart defects;
- Commitment to multi-disciplinary management, including genetic counselling; and
- Understanding and empathy in connection with the social and emotional difficulties encountered by adult patients with congenital heart disease and their relatives.

2.14 Pregnancy and heart disease

Objective²⁹

- To perform specialist cardiac evaluation, management, and follow-up of women with known or suspected heart disease before, during, and after pregnancy.

Knowledge

- Physiological, haemodynamic, haemostatic, and metabolic alterations during pregnancy
 - the normal echocardiogram during pregnancy and puerperium.
- Complications during pregnancy and puerperium in women without known cardiovascular disease:
 - thrombo-embolism;
 - hypertensive disorders (pre-/eclampsia);
 - ischaemic coronary events including ACS;
 - spontaneous coronary dissection, aortic, or vascular dissection;
 - arrhythmia;
 - peripartum cardiomyopathy.
- For patients with known or suspected cardiovascular disease who are contemplating pregnancy are pregnant or post-partum:
 - conditions for which pregnancy is contra-indicated (and those which justify early termination);
 - indications for genetic counselling;
 - conditions associated with a high risk of pregnancy-related cardiac complications for which intervention before considering pregnancy is appropriate;
 - appropriate follow-up during pregnancy and post-partum;
 - conditions requiring medical therapy during pregnancy;
 - situations in which cardiac intervention may be required during pregnancy;
 - management of anticoagulant therapy, with special attention to patients with valve prostheses;
 - endocarditis during pregnancy;
 - modalities of delivery and their major indications.
- Modalities for foetal assessment and diagnosis of genetic malformations;
- Cardiovascular pharmacology during pregnancy and lactation;
- Efficacy, risks, and contraindications associated with the various contraceptive methods according to the nature of the underlying heart disease.

Skills

The ability to:

- take a relevant history and perform an appropriate clinical examination;
- recognize the symptoms and signs associated with the haemodynamic changes associated with pregnancy;
- differentiate physiological from pathological dyspnoea during pregnancy;
- assess the cardiac risk of pregnancy on the basis of clinical evaluation and the interpretation of diagnostic procedures;
- recognize the necessity and undertake or refer for preventive cardiac intervention where appropriate;
- diagnose and manage the most frequent or serious cardiovascular complications during pregnancy;
- perform diagnostic procedures when indicated during pregnancy and post-partum;
- exercise testing;
- echocardiography and vascular ultrasound;
- other imaging techniques, paying due regard to the hazards of radiation exposure to the foetus;

- select drug therapies that can be used safely during pregnancy and breast feeding;
- manage pregnant patients who require ongoing anticoagulation for prophylaxis or treatment of thrombotic complications. This should be done in close collaboration with a tertiary expert centre;
- evaluate the foetal and maternal risk of different cardiac interventions;
- evaluate the cardiac condition after pregnancy;
- assess the cardiac risk of subsequent pregnancies.

Behaviours and attitudes

- Recognition of the importance of pre-pregnancy counselling and education for women with heart disease and their partners;
- Cooperation with gynaecologists and obstetricians with regard to recommendations on contraception;
- Cooperation during pregnancy, peri-partum, and post-partum with a multi-disciplinary team of gynaecologists, obstetricians, anaesthetists, neo-natologists, and midwives;
- Recognition of the importance of patient education on the symptoms of poor cardiac tolerance;
- Alertness to the risk of worsening cardiac status during the early post-partum period and the importance of communication with obstetricians and midwives.

2.15 Valvular heart disease

Objectives⁴

- To perform a specialist assessment and treatment of patients valvular heart disease (VHD):
 - diseases of native aortic, mitral, tricuspid and pulmonary valves and their combinations;
 - surgically or percutaneously repaired cardiac valves;
 - surgically or percutaneously implanted valvular prostheses.

Knowledge

- Haemodynamics of VHD;
- Pathophysiology: effects of VHD on the heart and on the circulation;
- Natural history of VHD;
- Strengths and limitations of diagnostic techniques, in particular echocardiography, and the value of additional procedures such as fluoroscopy, X-ray CT, magnetic resonance imaging, and invasive haemodynamic assessment;
- Values and limitations of different risk scores applied to VHD;
- Indications, benefits, and risks of medical therapy, surgical and percutaneous interventions for VHD;
- Indications for and management of anticoagulant therapy;
- Role of concomitant coronary heart disease in VHD and its impact on surgical management;
- Follow-up and medical management of native VHD;
- Follow-up and management of repaired valves, bioprostheses, mechanical prosthetic valves, and percutaneously repaired and implanted valves.

Skills

The ability to:

- take a relevant history and perform an appropriate clinical examination;

- use appropriate non-invasive or invasive diagnostic techniques;
- interpret results of diagnostic procedures;
- decide whether and when surgery or percutaneous intervention is indicated;
- assess risks and benefits of valvular interventions according to patient characteristics and the type of intervention; and
- recognize and manage the complications that may occur in patients with prosthetic valves or after valvular interventions.

Behaviours and attitudes

- Recognition of the importance of patient education with respect to the natural history of VHD, management of anticoagulation, and prophylaxis of bacterial endocarditis;
- Provision of balanced, readily understood, and appropriate information to the patient on the risks and benefits of different valvular interventions (repair/replacement);
- Explanation of the pros and cons of each type of prosthesis (biological and mechanical);
- Recognition of the importance of patient compliance;
- Commitment to work in a Heart Team with cardiovascular surgeons, anaesthetists, interventional cardiologists, and radiologists;
- Understanding of the appropriate frequency of follow-up with specific reference to the clinical condition after surgery or intervention.

2.16 Infective endocarditis

Objectives³⁰

Endocarditis

- To assess, diagnose, and treat patients with Infective endocarditis (IE) of native and prosthetic valves, prosthetic material, and indwelling devices such as pacemakers, ICDs, and catheters.

Prevention

- To perform preventive strategies in at-risk patients, including the prevention of nosocomial infections.

Knowledge

Endocarditis

- Epidemiology of endocarditis in relation to the ageing population, to surgical interventions, and to the increasing prevalence of prosthetic cardiac implants;
- Clinical features of different forms of endocarditis, including native valve, right heart, prosthetic valve (early and late after surgery), catheter and cardiac device-related infection (pacemaker, ICD);
- Classification of IE according to the mode of acquisition
 - (a) healthcare associated
 - (i) nosocomial;
 - (ii) non-nosocomial;
 - (b) community-acquired;
 - (c) intravenous drug abuse-related.
- Active or recurrent (relapse, re-infection);
- Pathology, pathophysiology, and microbiology;
- Symptoms and signs;
- Laboratory investigations including microbiological results and their limitations;

- Cardiac imaging including trans-oesophageal echocardiography, magnetic resonance imaging, and PET computer tomography;
- Medical management and monitoring;
- Surgical management;
- Complications and their management.

Prevention

- Measures for minimizing or preventing bacteraemia;
- Cardiac conditions at highest risk for IE;
- Procedures considered high risk for the development of IE;
- Indications for antibiotic prophylaxis.

Skills

Endocarditis

The ability to:

- take a relevant history and perform an appropriate clinical examination;
- select, use, and interpret echocardiographic approaches including trans-oesophageal echocardiography;
- perform an immediate prognostic evaluation on admission;
- select an appropriate antibiotic regimen;
- manage and monitor a patient with IE;
- organize immediate and long-term follow-up;
- determine the need for and timing of surgery;
- manage complications.

Prevention

The ability to:

- ensure good oral health in patients at risk;
- implement antibiotic prophylaxis for the prevention of IE in patients at high risk.

Behaviours and attitudes

- Commitment to working in a Heart Team with cardiac surgeons, intensivists, infectious diseases specialists, and microbiologists for diagnosis and management of IE;
- Recognition of the importance of patient and physician education on prophylaxis and the prevention of nosocomial infections;
- Recognition of the importance of patient compliance in prevention;
- Consistent provision of information to patients at risk and practitioners on the importance of prevention and the initial symptoms of endocarditis.

2.17 Heart failure

Objectives⁷

- To recognize the impact of heart failure on morbidity and mortality in the individual patient and in the population at large;
- To recognize heart failure and the different underlying causes;
- To perform specialist assessment and treatment of patients with heart failure;
- To work with patients and their families' primary care physicians, sub-specialists, nurses, and other healthcare professionals; and
- To organize structured follow-up of patients after discharge from hospital.

Knowledge

- Definition of heart failure;
- Pathophysiology of heart failure, systolic and diastolic dysfunction;
- Epidemiology and prognosis of heart failure with reduced and preserved ejection fraction (HFREF and HFPEF);
- Precipitating factors of heart failure;
- aHA stages of heart failure (A-D), Weber-Janicki classes of heart failure (peak $\dot{V}O_2$);
- International classification of functional limitation (NYHA class);
- Diagnostic procedures in the patient with known or suspected HF including chest X-ray, echo-Doppler,³¹ natriuretic peptides, cardiac X-ray CT and CMR, stress (including cardiopulmonary exercise) testing, cardiac catheterization;
- Importance of co-morbidities for prognosis of HF, including anaemia, renal impairment, depression, chronic obstructive pulmonary disease, and cachexia;
- Prognostic evaluation of the heart failure patient;
- Medical management of acute and chronic HF;
- Device management of HF: cardiac resynchronization therapy.^{5,32} See also Chapter 2.20.
 - (a) Implantable cardioverter defibrillator (ICD)
 - (i) To select patients with an indication for an ICD;
 - (ii) To have a good understanding of ICD implantation, device programming, and follow-up.
 - (b) Cardiac resynchronization therapy
 - (i) To select patients with an indication for CRT;
 - (ii) To have a good understanding of CRT implantation, device programming; and follow-up.
- Advanced supportive therapy, including (non-invasive) ventilation, ultrafiltration, and dialysis techniques;
- Interventional therapies such as conservative surgical and percutaneous procedures (including coronary revascularization and percutaneous interventions on the mitral valve), assist devices, artificial heart, and transplantation;
- Impact of coronary revascularization on the prognosis of HF patients;
- The role of exercise training programmes in HF patients;
- Complications of HF;
- Impact of optimized follow-up on prognosis of patients with HF (LV filling pressure monitoring, serial biomarkers determinations, biomarkers-guided therapy, telemedicine);
- Principles of palliative care.

Skills

The ability to:

- detect warning signs, symptoms, and clinical signs of HF;
- select and use diagnostic techniques to differentiate the underlying causes and precipitating factors of HF and to evaluate volume status, cardiac function, and pulmonary pressures;
- educate patients and their relatives about self-care management, and the importance of adherence to therapy;
- manage acute HF medically. See Chapter 2.27;
- manage chronic HF medically;

- deliver lifestyle advice and a home-based treatment strategy to patients;
- risk-stratify HF patients and select appropriate drug and other therapies;
- evaluate HF patients during follow-up and continuously adjust the treatment plan as appropriate.

Behaviours and attitudes

- Recognition of the importance of patient education with respect to the importance of lifestyle, exercise and weight loss, compliance with dietary measures, fluid restriction (when appropriate), and medication;
- Appreciation of the importance of rehabilitation and continued physical training;
- Commitment to work in a team with nurse practitioners or physician assistants;
- Commitment to work in team with electrophysiologists and heart failure specialists for the follow-up of patients with device therapy;
- Recognition of the importance of supportive and palliative care in patients with advanced heart failure.

2.18 Pulmonary arterial hypertension

Objectives³³

- To diagnose pulmonary hypertension;
- To distinguish between the different causes of pulmonary hypertension;
- To provide optimal management for patients with pulmonary hypertension.

Knowledge

- Pulmonary hypertension and its pathophysiological classification;
- Clinical classification and its rationale;
- Epidemiology of pulmonary hypertension, in particular pulmonary arterial hypertension (incidence, prevalence, aetiology, genetics, high-risk groups);
- Pathology and pathophysiology of different types of pulmonary hypertension;
- Clinical features of different aetiologies of pulmonary hypertension;
- Diagnostic criteria of pulmonary hypertension;
- Prognostic markers;
- Medical, surgical, and interventional management of pulmonary hypertension, including indications, contraindications, and adverse effects. Specifically disease targeted therapies and indications for pulmonary endarterectomy;
- Complications of pulmonary hypertension and their management.

Skills

The ability to:

- take a relevant history and perform an appropriate clinical examination;
- recognize clinical signs of pulmonary hypertension and its associated diseases;
- differentiate between pulmonary hypertension and other diseases with similar symptoms;

- interpret investigations including ECG, echocardiography, lung function tests, arterial blood gases, serum cardiac biomarkers, 6-min walk testing, CPX, ventilation–perfusion scanning, X-ray CT pulmonary angiography, CMR imaging, liver ultrasound, selective pulmonary angiography and haemodynamics derived from cardiac catheterization;
- set treatment goals and prescribe appropriate medical or invasive (surgical or interventional) management;
- provide advice on family planning;
- provide or refer for genetic counselling families affected by familial PAH;
- evaluate prognostic markers;
- initiate end-of-life care when appropriate;
- undertake screening for high-risk patients.

Behaviours and attitudes

- Cooperation with a multi-disciplinary team in delivering chronic disease management that may include general practitioners, respiratory physicians, internal medicine practitioners, surgeons, nurses, community healthcare workers, rehabilitation teams, and other professionals;
- Acknowledgement of the importance of expert centres (when available) and being prepared to refer patients when appropriate;
- Collaboration with patient associations.

2.19 Physical activity and sport in primary and secondary prevention

2.19.1 Sports cardiology

Objectives¹⁴

- To conduct strategies to implement healthy lifestyle, in particular physical and sports activities in the general population (primary prevention);
- To evaluate cardiovascular risk and exercise capacity (see Chapters 2.2 and 2.7.1);
- To recognize the characteristics of the athlete's heart;
- To appropriately detect contraindications to exercise/competition, and appropriately provide non-contraindication certificates.

Knowledge

- Exercise and sports physiology;
- Benefits of exercise training;
- Safety issues in exercise and sport;
- Diagnostic criteria and appropriate investigations in athletes with cardiovascular disease;
- Risk factors for and mechanisms of sudden cardiac death (SCD) during and after strenuous exercise;
- Specific population challenges and exercise programmes in appropriate settings;
- Recommendations for professional and recreational sports participation;
- SCD in patients, athletes, and in the population at large, and
- Mechanisms of action of illicit drugs.

Skills

The ability to:

- perform an individual CVD risk assessment using appropriate information from history, laboratory assessment including full lipid profile and clinical data (see Chapter 2.7.1);
- recognize pathological cardiovascular changes and differentiate them from the characteristic features of 'athlete's heart'; and
- use prevailing recommendations for eligibility for participation in competitive sports.

Behaviours and attitudes

Recognition of

- The role of active lifestyle, exercise, and sport in the promotion of health and in the prevention of the most threatening diseases including cardiovascular diseases.

2.19.2 Cardiac rehabilitation

*Objectives*¹⁴

- To evaluate and manage cardiovascular risk. See Chapter 2.7.1;
- To evaluate exercise capacity and causes of exercise intolerance. See Chapter 2.2;
- To provide appropriate rehabilitation and secondary prevention to patients with cardiovascular diseases.

Knowledge

- Multi-disciplinary risk factor intervention;
- Definition of comprehensive cardiovascular prevention and rehabilitation;
- Effects of behavioural change, including physical activity, nutrition, education and psychosocial risk factors on quality of life, cardiovascular risk, and outcome;
- Rehabilitation as a component of cardiac care and a promoter of secondary prevention;
- Target populations and risk stratification of patients;
- Psychological aspects of rehabilitation and exercise practice.

Skills

The ability to:

- take a relevant history and perform an appropriate clinical examination including the specific evaluation of the elderly patient;
- perform and interpret risk stratification using indicated tests;
- interpret a cardiopulmonary exercise test and distinguish different causes of exercise limitation;
- prescribe exercise-based rehabilitation programmes and other lifestyle interventions according to the patient's condition, in collaboration with other specialists when necessary; and
- motivate the patient to ensure long-term adherence to lifestyle changes and continuing exercise programmes.

Behaviours and attitudes

Recognition of:

- rehabilitation as a component of cardiac care;
- the importance of rehabilitation and secondary prevention for professional, personal and social life among patients with heart disease;

- the interplay of physical and psychological aspects of heart disease and the positive influence of exercise on cardiovascular risk factors;
- the role of other professionals including nurse specialists, physiotherapists, ergophysiologicals, psychologists, dieticians, and general practitioners in rehabilitation and secondary prevention; and
- the importance of patient and family education, and the role of other professionals in rehabilitation.

2.20 Arrhythmias

Objectives^{32,34}

- To assess and treat patients with arrhythmias and conduction disturbances.

Electrophysiology

- To select patients with an indication for electrophysiological evaluation;
- To have a good understanding of diagnostic and therapeutic electrophysiology.

*Pacing*³²

- To select patients with an indication for pacing;
- To perform temporary pacing;
- To have a good understanding of pacemaker implantation, device programming, and follow-up.

*Implantable cardioverter defibrillator (see Chapter 2.17)*⁵

- To select patients with an indication for an ICD;
- To have a good understanding of ICD implantation, device programming, and follow-up.

Cardiac resynchronization therapy (see chapter 2.17)^{5,32}

- To select patients with an indication for CRT;
- To have a good understanding of CRT implantation, device programming, and follow-up.

Genetics

- To diagnose and treat inherited arrhythmogenic disease, request genetic testing when appropriate, and counsel index case and family members.

Knowledge

- Classification and definition of:
 - (a) bradycardias;
 - (b) tachycardias
 - (i) supraventricular arrhythmias including atrial fibrillation and flutter;
 - (ii) ventricular arrhythmias.
- Epidemiology, pathophysiology, diagnosis, and clinical features of arrhythmias and conduction disturbances;
- Inherited arrhythmogenic diseases;
- Prognosis including risk evaluation;
- Principles of electrocardiography and electrophysiology, and relevant findings in different arrhythmias;

- High-risk features in the resting ECG such as long QT, short QT, Brugada ECG pattern, arrhythmogenic cardiomyopathy, and catecholaminergic ventricular tachycardia;
- Pharmacology of anti-arrhythmic drugs and knowledge of pro-arrhythmic effects of cardiovascular and other drugs and substances;
- Prevention of thrombo-embolic complications of atrial fibrillation and flutter;
- Invasive and device management of arrhythmias, including catheter ablation, and pacemaker, ICD, and surgical therapy;
- Importance of co-existing structural heart diseases, including coronary artery disease, in relation to the outcome and management of arrhythmias.

Skills

The ability to:

- take a relevant history and perform an appropriate clinical examination;
- classify arrhythmias from 12-lead electrocardiography;
- manage acute arrhythmias with drugs;
- manage acute arrhythmias with cardioversion;
- prescribe appropriate preventive pharmacological therapy;
- perform and interpret electrocardiographic monitoring (Holter and other long-term ECG recordings);
- interpret an electrophysiological study;
- identify and refer appropriate patients for catheter ablation and perform follow-up after catheter ablation;
- recognize indications for genetic screening for inherited arrhythmogenic diseases (channelopathies and cardiomyopathies).

Pacing, ICD, and CRT

The ability to:

- carry out temporary pacing;
- follow-up patients with pacemakers. Referral of patients to a tertiary expert centre in case of troubleshooting not due to battery exhaustion;
- basic follow-up of ICDs and CRTs in close collaboration with a tertiary expert centre.

Behaviours and attitudes

- Appreciation of the anxiety suffered by patients undergoing invasive arrhythmia management. Special emphasis should be given to patients with ICDs and having undergone repeated defibrillation shock therapy;
- Understanding of the palliative nature and potential adverse effects of pharmacological and non-pharmacological therapies;
- Team working with electrophysiologists and heart failure specialists for the follow-up of patients with device therapy.

2.21 Atrial fibrillation and flutter

Objectives^{6,35}

- To carry out specialist assessment and treatment of patients with atrial fibrillation and atrial flutter (AF).

Knowledge

- Epidemiology, pathophysiology, and prognosis of AF;
- Classification of AF;
- Diagnosis, clinical features, and impact on quality of life;
- Pre-disposing conditions;
- Importance of co-existing structural heart diseases on the outcome, and their implications for the management of AF;
- Diagnostic procedures tailored to the individual need;
- Diagnosis and prevention of atrial thrombosis and embolic complications,
 - Use of embolic risk scores and bleeding risk scores.
- Indications, contraindications, side-effects, and complications of:
 - antithrombotic therapy (including vitamin-K antagonists, thrombin receptor antagonists, factor Xa antagonists, and low-molecular-weight heparins);
 - rhythm vs. rate control therapy;
 - anti-arrhythmic drug therapy;
 - pharmacological cardioversion;
 - prevention of recurrences;
 - pharmacological control of ventricular rate;
 - direct current (DC) cardioversion;
 - Pacemaker and ICD therapy;
 - catheter ablation of AF;
 - surgical ablation of AF and occlusion of the left atrial appendage;
 - catheter ablation of the AV node;
 - atrial appendage occlusion devices.

Skills

The ability to:

- take a relevant history and perform an appropriate clinical examination;
- perform and interpret investigations including
 - electrocardiography;
 - echocardiography (TTE and TOE);
 - prolonged ECG monitoring (e.g. Holter monitoring);
 - exercise testing;
- apply scores for the assessment of thrombotic and bleeding risks;
- implement appropriate antithrombotic strategies for prevention of ischaemic stroke and systemic embolism;
- select patients for appropriate treatment as listed in knowledge;
- perform independently
 - antithrombotic therapy;
 - switch from one antithrombotic drug to another;
 - rhythm vs. rate control therapy;
 - anti-arrhythmic drug therapy;
 - pharmacological cardioversion;
 - pharmacological control of ventricular rate;
 - DC cardioversion.

Behaviours and attitudes

- Appreciation of patients' anxiety in relation to palpitation, anti-coagulant therapy, and invasive methods of management;
- Appreciation of the limitations and potential risks of anti-arrhythmic drug therapy;
- Appreciation of the importance of anticoagulant therapy;

- Appreciation of the limitations and potential risks of device therapies;
- Recognition of the importance of patients' and carers' education and information;
- Team working with general practitioners, nurses, electrophysiologists, surgeons, haematologists, and other healthcare providers.

2.22 Syncope

Objectives³⁶

- To define syncope;
- To differentiate syncope from the other causes of transient loss of consciousness;
- To assess and treat patients with syncope.

Knowledge

- The epidemiology and prevalence of different causes of syncope;
- The pathophysiology of syncope;
- Causes of syncope and other forms of transient loss of consciousness;
- Risk stratification of patients with syncope and indications for hospitalization;
- Diagnostic evaluation
 - (a) history from patient and eye-witnesses with special emphasis on the circumstances of the event;
 - (b) initial evaluation (physical examination, baseline ECG);
 - (c) appropriateness of additional testing:
 - (i) carotid sinus massage;
 - (ii) orthostatic challenge;
 - (iii) echocardiogram;
 - (iv) exercise stress testing;
 - (v) tilt testing;
 - (vi) electrocardiographic monitoring (long-term ECG);
 - (vii) cardiac catheterization and coronary angiography;
 - (viii) electrophysiological testing.
- Treatments (device based, pharmacological or physical manoeuvres) for:
 - (a) neurally mediated (reflex) syncope;
 - (b) orthostatic hypotension;
 - (c) cardiac arrhythmias (tachy and brady);
 - (d) structural cardiac or cardiopulmonary disease.

Skills

The ability to:

- take a relevant history and perform an appropriate clinical examination;
- perform or interpret the tests listed above;
- perform risk stratification;
- select appropriate treatment:
 - education and reassurance
 - physical manoeuvres;
 - drug therapy;
 - device implantation.

Behaviours and attitudes

- Understanding of the impact of syncope on the patient's lifestyle;

- Appreciation that syncope can be a transient symptom, and acceptance that it is not necessarily a disease;
- Willingness to collaborate with neurologists, elderly care specialists, and other care providers;
- Acceptance that the diagnosis of syncope is often presumptive;
- Recognition that many patients do not need any specific treatment apart from education and reassurance;
- Appreciation that therapies are often ineffective;
- Balance in assessing the risk–benefit and the cost–efficacy of pacemaker, ICD, and catheter ablation therapy.

2.23 Sudden cardiac death and resuscitation

Objectives

*Sudden cardiac death*³⁴

- To manage patients with aborted SCD, those with life-threatening arrhythmias and others with increased risk of SCD.

Resuscitation

- To be able to carry out basic (BLS) and ACLS.

Knowledge

Sudden cardiac death

- Definition of SCD;
- Epidemiology, aetiology, pathology, pathophysiology, and clinical presentation of pre-disposing conditions;
- Diagnostic work-up and risk stratification of survivors;
- Selection of appropriate long-term management options including pharmacological and device-based therapies;
- Current recommendations for primary and secondary prevention of SCD;
- Identification, risk stratification, and management of individuals at elevated risk, including family members of SCD patients.

Resuscitation

- Causes of cardiorespiratory arrest, identification of patients at risk, and early implementation of corrective treatment of reversible causes;
- Methods and guidelines of basic and advanced life support, including airway management, appropriate drug use, defibrillation, and pacing;
- Indications for not starting resuscitation or ceasing an initiated attempt;
- Pharmacology, actions, indications, and contraindications of the main drugs used in the management of a cardiac arrest.

Skills

Sudden cardiac death

The ability to:

- take a relevant history and perform an appropriate clinical examination;
- risk-stratify using the following techniques: echocardiography, ECG, Holter ECG, exercise testing;

- refer to tertiary centre for other forms of long-term ECG monitoring, catheterization and coronary angiography, electrophysiological study, and heart rate variability;
- follow-up SCD survivors.

Resuscitation

The ability to:

- quickly identify the cause of collapse;
- perform BLS and ACLS life support, including emergency and periresuscitation echocardiography;
- lead and coordinate the actions of an ACLS team;
- teach BLS.

Behaviours and attitudes

Sudden cardiac death

- Awareness of the importance of prodromal symptoms and signs;
- Appreciation of SCD survivor and family anxieties;
- Appreciation of the importance of patient education and secondary prevention;
- Understanding of the medical, psychological, and social problems arising in patients with frequent ICD activation;
- Awareness of the importance of considering a switch to palliative care in heart failure patients with an ICD.

Resuscitation

- Recognition of the urgency of the management of cardiac arrest;
- Appreciation of the importance of working in a team with lay persons, paramedics, and other medical personnel during resuscitation (BLS and ACLS);
- Understanding of the importance of regular audit of the basic and advanced life support programme.

2.24 Diseases of the aorta and trauma to the aorta and heart

Objectives³⁷

- To assess diseases of the aorta, and trauma to the aorta and heart;
- To implement appropriate medical therapy, and recognize the indications for interventional or surgical treatment.

Knowledge

- epidemiology, aetiology, pathology, genetics, pathophysiology, and clinical presentations of aortic disease, aortic root disease, and trauma to the aorta and heart including:
 - aneurysm of the thoracic aorta;
 - classification of aortic dissection;
 - Leriche syndrome;
 - aortic atherosclerosis types I–IV;
 - inflammatory aortic disease;
 - genetic conditions associated with aortic syndromes;
 - trauma of the heart including contusion and ACS;
 - trauma of the vessels including acute aortic dissection and aortic rupture.
- Strengths and limitations of different imaging modalities;
- Appropriate medical, interventional, and surgical management strategies.

Skills

The ability to:

- take a relevant history and perform an appropriate clinical examination, including pulse and BP measurements in different arms (and legs) and calculate for diagnostic purposes the ABI;
- recognize the need for and organize genetic and family screening where appropriate;
- select and interpret imaging studies (see chapter 2.3): chest X-ray, echocardiography (TTE, TOE), CMR, computed tomography, intravascular ultrasound, and angiography of the aorta and the heart;
- manage different aortic conditions with the appropriate treatment modality in a timely manner.

Behaviours and attitudes

- Team working with emergency and intensive care physicians, cardiovascular surgeons, interventional cardiologists, and radiologists;
- Recognition of the urgency required in managing patients with diseases of the aorta and cardiac trauma;
- Recognition of the need for long-term follow-up of patients with chronic aortic disease.

2.25 Peripheral artery disease

Objectives³⁸

- To assess and manage patients with PAD, including atherosclerotic and other diseases of the cervical (carotid and vertebral), mesenteric, renal, upper and lower limb arteries.

Knowledge

- Epidemiology and pathology of PAD;
- Diagnosis and assessment of PAD, including the ABI and various imaging modalities;
- General treatment modalities including smoking cessation, lifestyle modification, supervised exercise training programme, antiplatelet and anti-thrombotic drugs, lipid-lowering drugs, and antihypertensive therapies in patients with PAD;
- Indications for invasive (interventional and surgical) management and their relative merits in different situations;
- Prognostic stratification of PAD;
- Acute and critical limb ischaemia management.

Skills

The ability to:

- take a relevant history and perform an appropriate physical examination, especially the examination of peripheral pulses;
- identify the risk factors and select the appropriate management strategy;
- perform and interpret vascular ultrasound screening of abdominal aorta, carotid and femoral arteries;
- perform and interpret the ABI;
- interpret ultrasound, MR angiography, X-ray CT angiography, and invasive angiography in different vascular beds;
- classify and stage lower extremity artery disease.

Behaviours and attitudes

- Appreciation of the systemic nature of atherosclerosis and its implications for a patient in whom disease is manifested within a single territory. In particular, awareness of the association of PAD with disease in the coronary, carotid, and renal arteries;
- Recognition of the importance of risk-factor modification in prevention;
- A positive approach to encouraging patients to adopt a healthier lifestyle with specific emphasis on risk factors and walking;
- Team working with specialists such as cardiac rehabilitation specialists, interventional cardiologists, radiologists, vascular surgeons, and diabetologists.

2.26 Thrombo-embolic venous disease

Objectives³⁹

- To diagnose, treat and prevent:
 - deep vein thrombosis;
 - pulmonary embolism.

Knowledge

- Epidemiology of deep vein thrombosis;
- Risk factors for deep vein thrombosis
 - inherited thrombophilia (e.g. factor V Leiden and prothrombin gene mutations);
 - acquired thrombophilia (e.g. major surgery, trauma, immobilization, lupus anticoagulant, and elevated levels of antiphospholipid antibodies, malignancy, pregnancy, oral contraceptives, and myeloproliferative disorders).
- Pathophysiology of pulmonary embolism
 - increased pulmonary vascular resistance and ventilation–perfusion mismatch.
- Clinical presentation of superficial and deep vein thrombosis;
- Clinical presentation of pulmonary embolism;
- Diagnosis of deep vein thrombosis
 - Duplex examination of leg and pelvic veins.
- Diagnosis of pulmonary embolism by:
 - D-dimer and troponins;
 - ECG;
 - computed tomography;
 - echocardiography;
 - ventilation–perfusion scan;
 - MR angiography;
 - pulmonary angiography.
- Diagnosis of deep vein thrombosis
 - Ultrasound and Doppler imaging of leg and pelvic veins.
- Management of
 - Superficial venous thrombosis;
 - Deep vein thrombosis.
- Treatment of acute pulmonary embolism by:
 - anticoagulant therapy;
 - thrombolytic therapy;
 - embolectomy.
- Management of chronic thrombo-embolic pulmonary hypertension, including thrombo-endarterectomy;

- Preventive measures for DVT/pulmonary embolism:
 - compression stockings;
 - prophylactic anticoagulant therapy;
 - caval filter.

Skills

The ability to:

- take a relevant history and perform an appropriate clinical examination;
- interpret ECG, computed tomography, echocardiography, and ventilation–perfusion scanning signs of pulmonary hypertension and pulmonary thrombo-embolism;
- select appropriate therapy for acute pulmonary embolism and chronic thrombo-embolic pulmonary hypertension;
- diagnose and manage acute and chronic deep vein thrombosis;
- decide upon the duration of anticoagulant therapy for patients with thrombo-embolic venous disease.

Behaviours and attitudes

- Appreciation of the difficulties in diagnosing pulmonary embolism on the basis of symptoms and signs;
- Collaboration with other imaging experts including radiologists and nuclear imaging specialists;
- Ensuring patient understanding of the disease and the importance of compliance with, and the precautions required during long-term anticoagulant therapy.

2.27 Acute cardiovascular care

Objectives

- To perform specialist assessment and management of patients with cardiac emergencies;
- To be able to carry out basic (BLS) and ACLS. See Chapter 2.23;
- To collaborate with cardiac intensive care unit (ICU) cardiologists and intensive care physicians in the assessment and management of cardiovascular diseases in patients in the ICU.

Knowledge

- The early warning signs and symptoms of impending critical illness;
- Causes of cardiorespiratory arrest, identification of patients at risk, and early implementation of corrective treatment of reversible causes;
- Algorithms of basic (BLS) and advanced life support (ACLS), including the indications for not starting resuscitation or ceasing an initiated attempt. See Chapter 2.23;
- Criteria for admission and discharge from ICU;
- Epidemiology, pathophysiology, diagnosis and management of cardiac emergencies, including ACS, acute heart failure, cardiogenic shock, life-threatening arrhythmias, cardiac arrest and resuscitation, pericardial tamponade, pulmonary embolism, acute valve, and aortic disease;
- Detailed and specialized cardiovascular support
 - causes, diagnosis, consequences, and treatment of circulatory failure and shock;
 - indications, limitations, complications, and interpretation of non-invasive and invasive haemodynamic monitoring;

- pharmacology, indications, and contraindications of therapy used to support the circulation (fluids, inotropic, and vasoactive drugs);
 - indications for mechanical circulatory assist devices (ECMO, IABP, and other assist devices);
 - indications, contraindications, and complications of arterial and central venous access;
 - recognition and management of basic and complex arrhythmias, including arrhythmias during resuscitation.
 - Principles of respiratory support
 - respiratory physiology and pathophysiology: gas exchange, O₂ and CO₂ transport, hypoxia, hypo- and hyper-capnoea;
 - interpretation of arterial and venous blood gas samples;
 - causes, prevention, and management of respiratory insufficiency
 - emergency airway management;
 - principles of oxygen therapy and selection of oxygen administration devices;
 - knowledge of the indications, selection, and management of different methods of invasive and non-invasive mechanical ventilation (including the general principles of mechanical ventilation and heart–lung interactions);
 - effects of mechanical ventilation on the circulation;
 - pathogenesis, diagnosis, prevention, and principles of therapy for acute lung injury/acute respiratory distress syndrome (ALI/ARDS).
 - Principles of fluid, electrolyte, acid–base, and renal support
 - renal pathophysiology, regulation of fluid, electrolyte, and acid–base balance;
 - causes, diagnosis, prevention, and general principles of management of renal failure (acute, chronic, and acute on chronic);
 - general knowledge of renal replacement therapies (haemofiltration and dialysis);
 - treatment strategies for abnormalities of fluid, electrolyte, acid–base balance;
 - indications, contraindications, and complications of fluid therapy;
 - identification and prevention of the use or dose adjustments of nephrotoxic drugs in patients with renal impairment or failure.
 - Principles of metabolic and gastrointestinal support
 - blood glucose control homeostasis: pathophysiology, indications for and monitoring of therapy;
 - basic principles of gastrointestinal physiology, gut motility;
 - assessment and management of nutritional status and basal energy requirements;
 - prevention of stress ulceration.
 - Principles of prevention and treatment of infection
 - epidemiology and strategies for infection prevention in the ICU;
 - indications for microbiological sampling and interpretation of microbiological test results;
 - selection, indications, complications, interactions, and monitoring of common antimicrobial drugs;
 - basic knowledge of sepsis, septic shock, and systemic inflammatory response syndrome.
 - Other principles of support
 - causes, signs and symptoms, consequences, and methods of assessment of impaired neurological function;
 - pain assessment and control (appropriate analgesia);
 - drug therapy and assessment methods for sedation;
 - drug therapy and assessment methods for pain.
- Skills**
- The ability to:
- perform BLS and ACLS, and manage the patient in the post-resuscitation period;
 - develop a structured approach to identify, manage, and stabilize the patient with haemodynamic instability;
 - use emergency monitoring equipment and to timely identify cardiovascular abnormalities requiring urgent intervention;
 - participate in the decisions to admit, discharge, or transfer patients from the ICU.
 - Cardiovascular system support
 - perform arterial, central venous, and pulmonary artery catheterization;
 - measure and interpret haemodynamic variables;
 - use echocardiography appropriately in the acute and intensive care patient, including emergency and peri-resuscitation echocardiography, as an independent operator;¹²
 - initiate emergency cardiac pacing, either transvenous or trans-thoracic;
 - perform pericardiocentesis;
 - treat and manage basic and complex arrhythmias in the acute care patient;
 - select and use fluids, inotropic, vasoactive, and anti-arrhythmic drugs.
 - Respiratory system support:
 - identify the early signs of acute airway insufficiency and acute respiratory failure;
 - perform emergency tracheal intubation;
 - obtain and interpret data from blood gas samples (arterial, central, and mixed venous).
 - Comply with local infection control measures and appropriately manage antimicrobial drug therapy;
 - Correct fluid, electrolyte, metabolic, and glucose disorders;
 - Assess neurological function (e.g. Glasgow Coma Scale).
- Behaviours and attitudes**
- Address the physical and psychosocial consequences of critical illness for patients and their families;
 - Manage end of life situations and participate in the process of withholding or withdrawing treatment in cooperation with the multi-disciplinary team;
 - Communicate, collaborate and team-work with the health care team (nurses in the ICU, ICU cardiologists, intensivists and paramedical staff);
 - Readiness for quick availability, when requested by physicians, nurses, or staff.

2.28 The cardiac consult

2.28.1 The patient undergoing non-cardiac surgery

Objectives⁴⁰

- To cooperate with and assist other medical specialists in the prevention, assessment, and management of cardiovascular diseases in patients requiring non-cardiac surgery;
- To perform an individualized cardiac risk assessment in patients to be submitted to non-cardiac surgery;
- To perform an integrated multi-disciplinary pre- and peri-operative approach, in close cooperation with anaesthetists, but also with surgeons, other medical specialists, and paramedical professionals;
- To optimize the patient's pre-operative condition before non-cardiac surgery.

Knowledge

- Pathophysiology of systemic and cardiovascular stress responses to surgery;
- Pathophysiology of cardiovascular complications during surgery such as peri-operative infarction, rhythm disturbances, and heart failure;
- Patient-related, cardiac-related, and surgery-specific risk factors that influence cardiac risk for non-cardiac surgical interventions;
- Effects of most frequently used anaesthetic and sedative agents on cardiovascular function;
- Indications for and limitations of non-invasive testing for cardiac disease before surgery including ECG, echocardiography, various stress testing modalities, and X-ray computed tomography;
- Indications for pre-operative coronary angiography;
- Benefits of and clinical indications for pharmacological risk reduction strategies before and during surgery (beta-blockers, statins, antiplatelet therapy);
- Insight on alternative types of surgical procedure and local or regional anaesthetic techniques that can reduce cardiovascular risk;
- Indications for prophylactic myocardial revascularization before surgery;
- Role of monitoring techniques for peri-operative cardiac events;
- Risk evaluation, timing of procedure and risk reduction strategies in patients with specific conditions such as: post-revascularization (PCI or surgery), heart failure, valve diseases, valve prostheses, rhythm disturbances, and cardiac devices (ICDs and pacemakers).

Skills

The ability to:

- perform an individualized cardiac risk assessment by applying risk stratification indices according to the patient's clinical condition, type and urgency of surgery;
- select, perform, and interpret the non-invasive diagnostic tests before surgery (ECG, echocardiography, stress testing);
- discuss with the anaesthetist the peri-operative management regarding the type of surgery, anaesthetic technique, and peri-operative surveillance;
- select and implement the pharmacological and non-pharmacological interventions that can reduce cardiac risk during surgery;

- decide on the best timing of surgery and indicate the type of anti-thrombotic therapy in patients following revascularization procedures, in whom surgery cannot be delayed;
- check and optimize the control of all cardiovascular risk factors for long-term cardiovascular disease prevention;
- identify the need for cardiac follow-up after surgery.

Behaviours and attitudes

- Stimulation of multi-disciplinary team discussions on cardiovascular disease assessment and peri-operative strategies and management;
- Development and implementation of multi-disciplinary protocols for cardiovascular disease assessment and management;
- Awareness of the current cardiovascular prognosis of patients for whom non-cardiac surgery is planned.

2.28.2 The patient with neurological symptoms

Objectives

- To search for potential sources of cardiac embolism and other manifestations of atherosclerosis (coronary heart disease or peripheral arterial disease) in patients with ischaemic neurological symptoms and advise on appropriate short- and long-term management (secondary stroke prevention);⁴¹
- To cooperate with neurologists in the evaluation of patients with other neurological presentations such as syncope, dizziness, haemorrhagic stroke (secondary to hypertension, antiplatelet, or anticoagulant therapy), and neuromuscular diseases with possible cardiac involvement.

Knowledge

- Mechanism, epidemiology, clinical characteristics, and potential treatment options in patients with cardiac and aortic sources of embolism;
- Atherosclerosis as a systemic disease involving (simultaneously) other vascular territories;
- Importance and urgency of stroke prevention (anticoagulation) in patients with AF and fibrillation;
- Pharmacological and non-pharmacological therapies, including the indications for and relative merits of carotid interventions (end-arterectomy vs. stenting);
- In patients with non-ischaemic neurological manifestations:
 - the various causes of transient loss of consciousness;
 - the diagnosis and medical treatment of haemorrhagic stroke. Insight into the indications for neurosurgical interventions;
 - management of anticoagulant or antiplatelet therapy prescribed for cardiac conditions in patients with ischaemic or haemorrhagic stroke;
 - the pathophysiology, epidemiology, recommended cardiac evaluation, and management of patients with neuromuscular disorders involving the heart.

Skills

The ability to:

- use echocardiography, including trans-oesophageal echocardiography, and other techniques to search for potential sources of embolism;

- use ultrasound examination of the cervical arteries;
- define the need for further diagnostic work-up to search for other atherosclerotic manifestations, and advise on appropriate therapy;
- implement secondary prevention strategies, including lifestyle and pharmacological therapies.

Behaviours and attitudes

- Close team-work with neurologists and radiologists to determine the best management strategy for patients with ischaemic and non-ischaemic neurological conditions.

2.28.3 The patient with conditions not presenting primarily as cardiovascular disease

Objectives

- To manage cardiovascular disease in patients with diseases of other organs or systems that affect the cardiovascular system or are associated with cardiovascular involvement;
- To be particularly vigilant in the elderly, in patients with diabetes types I and II, chronic kidney disease, pulmonary disease, erectile dysfunction, and rheumatic disorders.

Knowledge Diabetes²⁰

- Definition, classification, epidemiology, pathophysiology, complications, and principles of therapy in diabetes;
- Diabetes as a cardiovascular risk equivalent and as a risk factor for heart failure (diabetic cardiomyopathy);
- Specificities of cardiovascular management in diabetic patients (e.g. revascularization strategies);
- Cardiovascular effects of antidiabetic drugs.

Chronic kidney disease

- Pathophysiology, epidemiology, and clinical implications of the complex interplay between the heart, the vasculature, and CKD (as both a risk factor and a consequence of cardiovascular disease)
- Clinical cardiac evaluation in patients with advanced CKD;
- Importance of appropriate renal function evaluation in every patient with cardiac disease;
- Primary and secondary pharmacological prevention of CKD (RAS inhibition);
- Pharmacological specificities (indications, contraindications, and dose adjustment) of cardiovascular drugs in patients with CKD;
- Strategies to avoid contrast nephropathy induced by cardiological examinations.

Others

- Epidemiology and clinical manifestations of, and treatment strategies for cardiovascular diseases in elderly patients and those with pulmonary diseases, erectile dysfunction, rheumatic disorders and other coexisting diseases.

Skills

The ability to:

- prevent, identify, and stratify the risk of cardiovascular disease including the specific evaluation of the elderly patient;
- provide appropriate counselling on diagnostic and therapeutic strategies;

- counsel the patient on long-term risk reduction.

Behaviours and attitudes

- Use of the cardiac consultation as an opportunity to identify cardiovascular risk factors and provide recommendations to the patient on lifestyle and medical therapy.

Supplementary material

Supplementary material is available at *European Heart Journal* online.

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CARDIOVASCULAR FLASHLIGHT

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Late-gadolinium enhancement in cardiac sarcoidosis

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A 65-year-old man was emergently admitted to our hospital for the evaluation of loss of consciousness. Electrocardiography showed sustained monomorphic ventricular tachycardia with heart rate of 215 b.p.m., which was treated with immediate cardioversion. Echocardiography revealed thinning and reduced motion of inferoseptal wall (Panel A, Supplementary material online, Video S1). Coronary angiography showed no stenosis or obstruction. Cardiac magnetic resonance imaging revealed thinning and reduced motion of inferoseptal wall (Supplementary material online, Video S2) and epicardial hyperenhancement from base to apex of the left ventricular septum, inferior wall and right ventricle (Panel B: short-axis view, Panel C: four-chamber view). Endomyocardial biopsy confirmed non-caseating granulomas with Langhans giant cells (Panel D). We diagnosed him with cardiac sarcoidosis. He underwent implantation of an implantable cardioverter-defibrillator and has been treated with prednisolone.

Cardiac magnetic resonance imaging, especially with the use of late gadolinium enhancement, is a useful modality to diagnose cardiac sarcoidosis and more than twice as sensitive for cardiac involvement as current consensus criteria of modified Japanese Ministry of Health guidelines. The location of hyperenhancement in cardiac sarcoidosis tends to be varied; however, there is a predilection for the basal or mid-ventricular septum in the majority of the cases. Hyperenhancement reflects myocardial damage, which is reported to be associated with future events of ventricular arrhythmia and poor outcome.

Supplementary material is available at *European Heart Journal* online.

