

Guidelines

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Association for European Paediatric and Congenital Cardiology recommendations for basic training in paediatric and congenital cardiology 2020

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Abstract

The recommendations of the Association for European Paediatric and Congenital Cardiology for basic training in paediatric and congenital cardiology required to be recognised as a paediatric cardiologist by the Association for European Paediatric and Congenital Cardiology are described below. Those wishing to achieve more advanced training in particular areas of paediatric cardiology should consult the training recommendations of the different Association for European Paediatric and Congenital Cardiology Working Groups available on the Association for European Paediatric and Congenital Cardiology website (www.aepc.org) and the respective publications 1–6. The development of training requirements is the responsibility of the Educational Committee and the Association for European Paediatric and Congenital Cardiology Council in collaboration with the Working Groups of the Association for European Paediatric and Congenital Cardiology. Trainees should be exposed to all aspects of general paediatric and congenital cardiology from fetal life to adolescence and adulthood. Centres performing generalised and specialised work in paediatric and congenital cardiology should be committed to deliver postgraduate training. At each training institute, trainers should be appointed to supervise and act as mentors to the trainees. Association for European Paediatric and Congenital Cardiology will provide basic teaching courses to supplement the training process.

The recommendations of the Association for European Paediatric and Congenital Cardiology for basic training in paediatric and congenital cardiology required to be recognised as a paediatric cardiologist by the Association for European Paediatric and Congenital Cardiology are described below. This manuscript has been reviewed by the Association for European Paediatric and Congenital Cardiology Council, and this manuscript has been approved by the Association for European Paediatric and Congenital Cardiology Council for publication in *Cardiology in the Young* as an official position paper of Association for European Paediatric and Congenital Cardiology.

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The development of training requirements is the responsibility of the Educational Committee and the Association for European Paediatric and Congenital Cardiology Council in collaboration with the Working Groups of the Association for European Paediatric and Congenital Cardiology.

Trainees should be exposed to all aspects of general paediatric and congenital cardiology from fetal life to adolescence and adulthood. Centres performing generalised and specialised

work in paediatric and congenital cardiology should be committed to deliver postgraduate training.

At each training institute, trainers should be appointed to supervise and act as mentors to the trainees. Association for European Paediatric and Congenital Cardiology will provide basic teaching courses to supplement the training process.

The recommendations outlined below should be regarded as the minimum requirements to become a paediatric and congenital cardiologist. Care of patients with CHD and heart disease in general should be provided by paediatric congenital cardiologists and adult congenital cardiologists. Both specialities can originate from education as a paediatric cardiologist or adult cardiologist depending on the specific requirements for education of specialists and transition of patients in each individual European country. This document focusses on the education as a paediatric cardiologist based on the education in paediatrics. As CHD patients are treated from fetal life until adulthood depending on the respective agreement of transition to the adult congenital cardiologist, the speciality is named “paediatric and congenital cardiologist” throughout this document. The training recommendations to become an adult congenital cardiologist are stated separately by the European Society of Cardiology.^{8,9} Advanced training programmes in special fields of paediatric and congenital cardiology (e.g., catheterisation, imaging, intensive care, electrophysiology, etc.) are highly encouraged to be followed after the basic training programme to ensure a high-level treatment of CHD patients. Details on advanced training programmes are addressed in the respective Association for European Paediatric and Congenital Cardiology Working Group publications.¹⁻⁷

Duration of training

The entry criteria for training in paediatric and congenital cardiology are a minimum of 3 years training in general paediatrics (including at least 6 months in neonatal/paediatric intensive care). The duration of training in paediatric and congenital cardiology is a minimum period of 3 years.

Objectives of training and trainee tasks

Objectives

The fundamental objectives of training are to provide the best quality of care for the patients and a compassionate attitude to the patients and their parents or guardians.

- Training programmes in paediatric and congenital cardiology should provide an environment for acquiring the knowledge, skills, attitudes and competence, and clinical judgement essential for the speciality.
- Programmes should have an appropriate balance between clinical services, training, and academic endeavours.
- Programmes should encourage a commitment to continuous education, teaching, research, critical thinking, and deep insight into the practical and theoretical problems of the speciality. Therefore, it is important that the trainee undertakes clinical or basic research aiming for presentation and publication of the findings.
- The trainee should be educated in specialised departments skilled in all fields of CHD management and officially accredited for this speciality.

Trainee tasks

To ensure sufficient experience, the trainee should participate in an appropriate variety of patient management:

Out-patients: The trainee should be involved in the management of out-patients under supervision. These should include patients from neonates to adolescents with a variety of congenital and acquired cardiac diseases and adults with CHD.

In-patients: The trainee should be involved in the management of in-patients under supervision. These should include patients from neonates to adolescents with a variety of congenital and acquired cardiac diseases and adults with CHD.

Intensive care: The trainee should spend ample time in the ICU and should become involved in the treatment of a variety of congenital and acquired cardiac diseases in patients of all age groups.

Multidisciplinary meetings: The trainee should regularly attend multidisciplinary meetings where management decisions are discussed.

On-call commitment: The trainee should participate in the on-call schedules of the department with backup support provided by a paediatric or adult congenital cardiologist in order to achieve adequate experience in the management of emergencies.

General training requirements

The 3 years of training consists of different basic components of the specialty as mentioned under point 3 “Specific Training” (such as morphology/embryology/epidemiology, genetics, imaging, fetal cardiology, haemodynamic and catheterisation, cardiac rhythm disorders, and cardiac intensive care).

The training can be completed in more than one institution. The institutions have to fulfil the training criteria for the particular area.¹⁰

Participation in appropriate Association for European Paediatric and Congenital Cardiology-recognised basic teaching courses is encouraged. For further details, see also the recommendations of the respective Association for European Paediatric and Congenital Cardiology Working Groups.¹⁻⁶

Basic knowledge and skills

Epidemiology, genetics, embryology, normal and abnormal anatomy of the cardiovascular system

A basic understanding of these should be achieved during the first year by regular teaching sessions and by attending appropriate courses. Attendance at a course on anatomy in CHD shall be encouraged. For details, see the subsequent chapter under point 3: “Specific Training.”

Physiology, pathophysiology, and haemodynamics of CHDs

Understanding of the principles of cardiovascular physiology and pathophysiology of the congenital lesions is essential. The knowledge should be applied theoretically and as well as in the clinical setting. Most common lesions are listed in Table 1.

Basic clinical and diagnostic examination

History taking and clinical physical examination. The trainee has to acquire the capability and knowledge to take a detailed history focussing on cardiovascular disorders. To take the patients history, a relationship with the patient and/or the parents based on trust and empathy has to be established. The trainee is expected to focus on the clinical history relevant to the cardiovascular disorder which

Table 1. Most common congenital and acquired cardiac diseases from fetus to adult

Non-cyanotic cardiac defects
• Atrial septal defect
• Partial anomalous pulmonary venous connection(s)
• Ventricular septal defect
• Atrioventricular septal defect
• Patent arterial duct
• Aorto-pulmonary window
• Pulmonary stenosis (valvular, infundibular, supra-valvular, and peripheral)
• Ebstein anomaly of the tricuspid valve (mild form)
• Double-chambered right ventricle
• Aortic stenosis (valvular, subvalvar, and supra-valvar)
• Coarctation of the aorta and interrupted aortic arch
• Mitral valve disease (prolapse, cleft, parachute mitral valve, double orifice mitral valve)
• Double discordance (L-transposition of the great arteries)
• Coronary artery fistula
Cyanotic cardiac defects
• Pulmonary atresia with intact ventricular septum and with ventricular septal defect
• Critical pulmonary stenosis
• Tetralogy of Fallot
• Transposition of the great arteries
• Double-outlet right ventricle
• Truncus arteriosus
• Hypoplastic left heart syndrome
• Total anomalous pulmonary venous connection
• Univentricular atrioventricular connection
• Complex CHD associated with abnormalities of cardiac position and situs
Critical CHD requiring emergency postnatal treatment (neonatal and perinatal management based on prenatal diagnosis)
• Transposition of the great arteries with restrictive foramen ovale
• Hypoplastic left heart syndrome with restrictive/closed foramen ovale
• Mitral valve dysplasia syndrome
• Ebstein anomaly of the tricuspid valve or tricuspid valve dysplasia with “circular shunt”
• Restrictive total anomalous pulmonary venous connection (very difficult for prenatal diagnosis)
Critical ductal-dependent CHD (stabilisation of circulation met postnatal start of prostaglandin)
• Left heart lesions: aortic stenosis, hypoplastic left heart syndrome
• Systemic ductal-dependent lesions in complex CHD (e.g., tricuspid atresia with transposition of the great arteries, double-inlet left ventricle with hypoplastic aortic arch)
• Transposition of the great arteries
• Double-outlet right ventricle – transposition type (Taussig–Bing anomaly)
• Critical pulmonary stenosis and pulmonary atresia with intact ventricular septum
• Ductal-dependent pulmonary circulation (defects with fetal left to right or bidirectional shunt across the arterial duct)
• Coarctation of the aorta/interrupted aortic arch

(Continued)

Table 1. (Continued)

Cardiovascular symptoms and disorders
• Failure to thrive
• Dyspnoea
• Palpitations
• Oedema
• Cyanosis
• Chest pain
• (Pre)-Syncope
• Pulmonary hypertension
• Inflammatory cardiovascular disease (rheumatic heart disease, Kawasaki disease)
• Cardiomyopathies
• Endocarditis
• Myocarditis
• Cardiac anomalies associated with genetic disorders and syndromes
• Acquired valvular diseases
• Pericardial diseases
• Cardiac tumours
Cardiac arrhythmias
• Supraventricular arrhythmias
• Fetal supraventricular tachycardia/atrial flutter (transplacental treatment)
• Ventricular arrhythmias
• Complete congenital atrio-ventricular block with normal cardiac anatomy
• Complete atrio-ventricular block with CHD (left atrial isomerism, L-transposition of the great arteries)
• Fetal sinus bradycardia (risk for long QT syndrome)
Fetal functional cardiac disorders
• Premature restriction/closure of the arterial duct – risk of postnatal pulmonary hypertension
• Right ventricular outflow tract obstruction due to twin-to-twin transfusion syndrome
• Hypertrophic cardiomyopathy due to twin-to-twin transfusion syndrome or maternal diabetes
• Premature closure of the foramen ovale, commonly secondary to arrhythmia (atrial ectopic tachycardia, junctional ectopic tachycardia)

includes the family and social history as well as the present symptom orientated history and past history. It is important to recognise co-morbidities and associated risk factors.

The findings taken from the clinical history should be complemented and objectively evaluated by performing a complete clinical examination. The clinical examination should include the examination of the heart, lungs, and the vascular system. A special focus is on auscultation of the heart. A growing ability to distinguish variance in heart sounds and different murmurs, differentiating the likely innocent murmur from the pathological one is expected. The arterial pulses should be evaluated and the heart rate and rhythm examined. The trainee should know how to measure the blood pressure and measurement limitations. The clinical signs of under-perfusion and ascites or oedema should be recognised by the trainee. The clinical examination should lead to an accurate observational summary of the clinical status of the patient with the intention to decide on a diagnostic and therapeutic strategy.

Electrocardiography (12-lead electrocardiography). The trainee should obtain basic knowledge and experience concerning evaluation of the electrical activity of the heart. This includes the interpretation and formal reporting of a normal and abnormal electrocardiogram, audited by a trainer. The focus is on electrophysiological rhythm disorders, hypertrophy, and signs of conduction disorders.

24 hours electrocardiography and exercise testing. The trainees should become familiar with the 24 hours electrocardiography, exercise testing protocols, and the cardiorespiratory exercise test as well as with electrocardiography monitoring for a longer time period and implantation of an implantable loop recorder. In detail, tests' indications, limitations, and contraindications should be known. The trainee is expected to perform and systematically interpret the different test results in the clinical context. Complications of the exercise test and their management should be known.

Chest X-ray and the principle of X-ray dose reduction. The trainee should learn to interpret chest X-rays of the patients under the care of the department at the start of training. Trainees' interpretation and/or reporting of chest X-rays should be supervised and audited by a paediatric and congenital cardiologist, or by a specialised radiologist. The trainee should be acquainted with the interpretation and the clinical use of chest X-rays by the end of the training.

The trainee should gain sound knowledge of radiation protection of patients and staff and the effects of radiation on human cells, tissues, and the growing body according to the as low as reasonably achievable (ALARA) concept. This also applies to the use of radiation in all types of X-ray-oriented imaging techniques: diagnostic and interventional cardiac catheterisation procedures and CT scanning. The requirements for an exam on radioprotection are addressed by each individual country's regulations.

Clinical knowledge of cardiovascular diseases

Knowledge of the cardiovascular symptoms and signs as well as their interpretation is mandatory. The clinical work should be under the supervision and guidance of an experienced paediatric and congenital cardiologist and focus on the following issues:

- The trainee acquires knowledge of the embryology, detailed anatomy, physiology, epidemiology, and natural history of cardiac disorders.
- The trainee is able to make an accurate anatomical and physiological diagnosis on the basis of clinical information and investigations. This includes the common scenarios as:
 - Evaluation of the child with a cardiac murmur.
 - Evaluation of children and adolescents with chest pain, palpitations, pre-syncope, and/or syncope.
- The trainee can interpret clinical information and the results of non-invasive and invasive investigations to determine the optimal treatment strategy.
- The trainee knows indications, contraindications, and limitations for medical, surgical, and interventional treatment.
- The trainee shall acquire the ability of decision-making regarding diagnostic tools, therapeutic management, and outcome.
- The trainee understands the importance of close collaboration with colleagues from other disciplines, such as surgery, radiology, anaesthesia, and intensive care.
- The trainee appreciates the role of the nursing staff, social workers, psychologists, physiotherapists, and play specialists in the care of children and adults who need intensive investigation and surgery.

Management of cardiovascular diseases

The trainee should acquire knowledge of different types of medical, surgical, and interventional treatments of cardiovascular diseases (see Table 1). This should include the indications, results, and associated complications of the treatment as well as the short term and late outcomes. Focus is expected on the following issues:

- The trainee acquires knowledge of the actions and side-effects of cardiovascular and non-cardiovascular drugs and their interactions with other pharmacological substances in different diseases and at different ages.
- The trainee focusses on the importance of a multi-disciplinary approach: paediatric and congenital cardiologists, interventionalists, radiologists, and cardiac surgeons have to be involved in the decision-making process. The detailed pre-operative or

Table 2. Underlying principles of training

Teaching and learning methods
• Learning with peers
• Work-based experiential learning
• Paediatric cardiology on call
• Consultant-led ward rounds
• Multidisciplinary team meetings
• Formal postgraduate teaching
• Independent self-directed learning
Assessment
• Work place based
• Clinical assessment, case discussion, patient surveys, supervision, feedback
• Record of assessment, progress logbook, portfolio of educational activities
• Multisource feedback

pre-interventional assessment should be encouraged and other sub-specialities be involved, if needed.

Basic, underlying principles of training are summarised in Table 2 (adapted from Ref. 3).

Research

The trainee is expected to acquire a sound knowledge of methodologies used to perform research and the capability to analyse published research.

- The trainee is aware of the principles of ethical issues.
- The trainee acquires knowledge on study design and adequate statistical methods to be able to critically review scientific articles.
- The trainee participates in ongoing research projects to learn how to successfully perform a research project.
- The trainee becomes familiar with setting up a clear research aim and objectives to subsequently design a study. Therefore, the trainee focusses on setting up protocols, data analysis, interpretation of data, systematic literature review, and scientific writing.

The trainee acquires knowledge on the importance of clinical audits and the principals of performing these. The importance of clinical audits for patient care and the relevance of important data sources are understood by the trainee.

The trainee is expected to continuously update the knowledge and keep up to date with ongoing developments in the field to assure academic improvement and quality assessment. Paying attention to these issues will allow the trainee to become familiar with a concept of lifelong learning to secure a positive long-term career development.

Specific training requirements

The special topics and issues in paediatric and congenital cardiology are addressed by the respective working groups of the Association for European Paediatric and Congenital Cardiology.

In accordance, the specific training requirements concerning knowledge, skills, and attitude are mentioned in detail per topic.

Morphology, embryology, anatomy, and epidemiology of cardiovascular disease

The trainee is expected to gain profound insight in cardiovascular morphology and pathology. Participation in an Association for European Paediatric and Congenital Cardiology-acknowledged course on cardiovascular morphology and pathology is strongly recommended for all trainees. Upon completion of the course, the trainee is expected to have the following knowledge:

Knowledge:

- Principles of cardiovascular development, including the genetic factors and influence of embryonic/fetal haemodynamics.
- Anatomy of the normal heart including its topographical relationships in various periods of life.
- Principles of the sequential segmental analysis of congenitally malformed heart.
- Morphology of the cardiac conduction system.
- Morphological features of:
 - septal defects
 - anomalies of the outflow tract
 - anomalies of the right heart
 - anomalies of the left heart
 - anomalies of the systemic and pulmonary veins
 - anomalies of the aorta and connected arteries
 - anatomy of functionally univentricular hearts
 - morphology of lateralisation defects'
 - morphological features of clinically significant coronary abnormalities
- Up-to-date terminology of CHDs as recommended by the Association for European Paediatric and Congenital Cardiology Coding Committee and current revisions of the International Classification of Diseases.
- Histopathological characteristics and staging of pulmonary hypertension.
- Morphological features of CHD in the adult population (including natural remodelling, post-surgical remodelling, and other morphological topics relevant for this population).

Skills:

- Initiate the adequate management of the patient upon morphological and pathophysiological diagnosis.
- Interpret the results of the various imaging techniques (echocardiography, CT scan, MRI, angiography) according to the knowledge acquired in cardiac morphology.

Attitude:

- Coordination of patient management with involvement of the potential sub-specialties (geneticists, surgeons).

Genetics, basic science, and myocardial disease

The trainee should acquire knowledge and experience in the basis of genetics and on diagnosis and treatment of inherited diseases associated with cardiovascular disorders.

Knowledge:

- Principles of Mendelian monogenic human diseases being autosomal dominant, autosomal recessive, and X-linked:
 - Mitochondrial patterns of inheritance

- Polygenic cardiovascular diseases
- Genes, genome, chromosomes
- Methods: Sanger sequencing, next-generation sequencing, fluorescence *in situ* hybridisation, comparative genomic hybridisation
- Relevance of polymorphisms and mutations
- Diagnosis and clinical presentation of most frequent syndromes, including:
 - Trisomy 21, 13, 18, and X0 (Turner)
 - 22q11 microdeletion syndrome
 - 7q11 microdeletion syndrome (Williams–Beuren) and elastin gene mutations
 - Noonan syndrome and RASopathies
 - CHARGE syndrome
 - Alagille syndrome
 - Holt–Oram syndrome
 - Char syndrome and other syndromes
- Diagnosis, clinical presentation, and treatment of cardiomyopathies, including:
 - Hypertrophic-, dilated-, restrictive-, and non-compaction cardiomyopathy
 - Mitochondrial diseases and Barth syndrome
 - Sarcomeric cardiomyopathies
 - Storage diseases and other inborn errors of metabolism
 - Neuromuscular disorders
 - Arrhythmogenic cardiomyopathy
- Diagnosis, clinical presentation, and treatment of inherited arrhythmia syndromes, including:
 - Long and short QT syndrome
 - Brugada syndrome
 - Catecholaminergic polymorphic ventricular tachycardia
- Diagnosis, clinical presentation, and treatment of aortopathy syndromes, including:
 - Marfan syndrome
 - Loeys–Dietz syndrome
 - Ehlers–Danlos syndrome, Thoracic Aortic Aneurysm and Dissection syndrome
 - Arterial tortuosity syndrome

Skills:

- Evaluate the family history and draw a pedigree including the ability of interpretation (problems with pedigree interpretation as incomplete penetrance, variable expressivity, and age-related patterns of expressivity).
- Patient counselling (including prenatal) in collaboration with the geneticist after genetic testing and management of the uncertainties associated with genetic testing.

Attitude:

- Ability to communicate sensitively regarding to genetic family disorders.
- Recognition of importance of a multidisciplinary team, including geneticists and genetic counsellors.

Imaging module

The trainee should gain knowledge about the choice and frequency of imaging modality according to the lesion-specific patient characteristics as well as the strengths and weaknesses of each imaging modality.

Echocardiography

The trainee should become familiar with the cardiac anatomy and physiology of congenital and acquired heart diseases using echocardiography following the sequential segmental analysis.

Knowledge:

- Physics of ultrasound imaging.
- Practical use of ultrasound equipment.
- Patient preparation.
- Indications for transthoracic and transoesophageal echocardiography in patients with congenital and acquired heart disease.
- Indications for fetal echocardiography.
- Echocardiography techniques (two-dimensional and three-dimensional imaging, Doppler imaging, M-mode, contrast echocardiography, speckle-tracking echocardiography, stress echocardiography).
- Standard echocardiographic views.
- Quantification methods.¹¹
- Monitoring of interventional and surgical procedures using transoesophageal echocardiography.
- Limitations of echocardiographic techniques.
- Major echocardiographic developments.

Skills:

The ability to:

- independently perform, interpret, and report transthoracic echocardiographic studies in patients with all forms of congenital and acquired heart diseases, both pre- and post-operatively.
- quantify cardiac structures including measurements of cardiovascular structures, ventricular size, and function.
- perform basic transoesophageal studies.
- interpret fetal echocardiography studies.

Attitudes:

- Interactive co-operation with paramedical staff, sonographers, referring colleagues, and cardiac surgeons.
- Be able to recognise the advantages and disadvantages of echocardiography in various clinical situations and in relation to other imaging modalities.
- Be able to discuss echocardiography findings within a multidisciplinary team.
- Be able to decide for therapeutic, medical, interventional, and surgical treatment in the acute and chronic management of CHD from fetal to adult age.

Cardiovascular CT and cardiovascular MRI

The trainee should become familiar with cross-sectional cardiovascular imaging methods, their diagnostic potential, and limitations including both CT and cardiovascular MRI.^{7,12}

Knowledge:

- Basic knowledge of CT physics.
- Basic knowledge of cardiovascular magnetic resonance physics.
- Basic knowledge of cardiovascular magnetic resonance pulse sequences and cardiovascular magnetic resonance methodologies.
- Basic knowledge of CT techniques.
- Cardiovascular magnetic resonance: safety and patient preparation.
- CT: radiation exposure and protection, patient preparation.
- Indications for CT in patients with congenital and acquired heart disease.
- Indications for cardiovascular magnetic resonance in patients with congenital and acquired heart disease.
- Indications and complications of CT contrast agents.

- Indications and complications of cardiovascular magnetic resonance contrast agents.
- Limitations of CT and cardiovascular magnetic resonance.

Skills:

The ability to:

- select appropriate indications and avoid contraindications for CT and cardiovascular magnetic resonance scans.
- display and interpret CT and cardiovascular magnetic resonance images in the clinical context.

Attitudes:

- Be able to recognise the advantages and disadvantages of CT and cardiovascular magnetic resonance in various clinical situations and in relation to other imaging modalities.
- Be able to discuss cardiovascular magnetic resonance/CT findings within a multidisciplinary team.
- Interactive co-operation with paramedical staff, cardiovascular magnetic resonance/CT technicians, radiologists, referring colleagues, physicists, and cardiac surgeons.

Nuclear cardiology

The trainee should become familiar with nuclear cardiology methods, their diagnostic potentials, and limitations.

Knowledge:

- Basic principles and techniques of radionuclide imaging (single photon emission computed tomography (SPECT), positron emission tomography (PET), lung ventilation/perfusion studies, PET-CT, SPECT-CT).
- Radiation exposure and safety.
- Indications for radionuclide imaging in patients with congenital and acquired heart disease.
- Limitations of radionuclide imaging.

Skills:

- The ability to interpret the results of radionuclide imaging.

Attitudes:

- Interactive co-operation with paramedical staff, nuclear medicine physicians, referring colleagues, and physicists.
- Be able to recognise the advantages and disadvantages of radionuclide imaging techniques in various clinical situations and in relation to other imaging modalities.
- Be able to discuss radionuclide findings within a multidisciplinary team.

Cardiac catheterisation and angiocardiography

Haemodynamic investigations and angiocardiography

The techniques of cardiac catheterisation and angiocardiography will be encountered throughout the period of training.

The trainee should learn the technique of cardiac catheterisation and angiocardiography and also become proficient in haemodynamic calculations.

The trainee should learn good practices in the catheterisation laboratory and concerning the method of angiocardiography meaning its benefits, limitations, and the associated risks.

The trainee should be able to perform diagnostic catheterisations independently by the end of the training period. However, these expectations will be governed by the regulations in individual countries (see recommendations of Association for European Paediatric and Congenital Cardiology Interventional Working Group, update under revision).¹

Interventional catheterisation

The trainees should be involved in common diagnostic and interventional procedures as well as in emergency procedures. The goal is to provide basic knowledge of haemodynamics, angiography, radiation safety, indications, risks, and benefits of interventional procedures in children and adult congenital patients.¹

Knowledge:

- Basic equipment for diagnostic and interventional procedures.
- Basic techniques of interventional procedures in paediatric and adult CHD.
- Imaging techniques needed to plan and perform interventional procedures.
- Views of cardiovascular angiography and peri-procedural imaging.
- Indications and complications of contrast agents.
- Indications and complications of drugs used for invasive procedures (heparin, isoproterenol, adenosine, etc.).
- Indications, limitations of diagnostic and interventional procedures.
- Advantages and disadvantages of medical versus interventional and surgical management.
- Potential complications of diagnostic and interventional techniques with appropriate management strategies, including post-procedural and follow-up complications.
- Vascular access techniques and potential complications with appropriate management strategies.

Skills:

- Pre-procedural evaluation and care.
- Interpretation of haemodynamics and oximetry including calculation of blood flow, shunts, and resistances.
- Interpretation of angiographic images.
- Reporting of catheter data.
- Interpretation of catheter data, relationships with non-invasive evaluation, and indication to interventions/surgery.
- Integrate transoesophageal and intracardiac echocardiography monitoring during interventional procedures.
- Management of post-procedural care.

Attitudes:

- Appreciate the anxiety and concerns of patients and relatives undergoing interventional procedures.
- Be able to discuss the advantages and disadvantages of different devices used in different clinical situations with patients.
- Appreciate the importance of radiation protection.
- Appropriate self-confidence and recognition of limitations.
- The importance of co-operation with cardiac surgeons.

Diagnosis and treatment of cardiac rhythm disorders

Clinical electrophysiology

The trainee should acquire knowledge concerning clinical symptoms, diagnosis, and management of common paediatric arrhythmias. Evaluation of arrhythmia symptoms and skills in electrocardiography differential diagnosis of common supraventricular tachycardias are essential. The trainee should acquire expertise in the acute pharmacological management of children with arrhythmias.

Knowledge:

- Understanding the mechanisms of tachycardias (re-entry, automatic, triggered).

- Types, recognition, and differential diagnosis of supraventricular tachycardias.
- Paediatric dosages and side-effects of drugs used for management of common supraventricular tachycardias.
- Aetiology and prognosis of paediatric ventricular arrhythmias and recognition of the common benign forms.
- Recognition, diagnosis, and management of post-operative arrhythmias in the ICU.
- Aetiology, evaluation, therapy, and prognosis of atrioventricular conduction block.
- Basic knowledge on diagnosis and treatment of fetal arrhythmias.
- Confirm the suspicion of cardiac syncope.
- Indication, performance, interpretation, and limitations of a tilt table testing with regard to its physiological principles and the diagnosis of (pre-)syncope.
- Scientific background, theoretical limitations, and cost effectiveness of general electrocardiography screening.
- The role of sport activity in preservation of health and its role in provocation of sudden cardiac death.

Skills:

- Competence in interpretation of standard electrocardiography, ambulatory (Holter) electrocardiography, exercise electrocardiography, and event-based monitoring.
- Acute pharmacological management of children with arrhythmia.
- External cardioversion and defibrillation.

Attitudes:

- Awareness and appreciation of the psychological impact in patients undergoing pharmacological and invasive anti-arrhythmic therapy.
- Collaboration with electrophysiologists and heart failure specialists for patients with implanted devices.

Invasive electrophysiological studies and catheter ablation

The trainee should be involved in common diagnostic and ablation procedures. The focus is to provide basic knowledge of electrophysiological studies, indications, risks, and benefits of invasive electrophysiology in children and adult CHD patients.

Knowledge:

- The trainee should know the indications for an invasive electrophysiological study and a catheter ablation in paediatric and CHD patients.
- Understanding the common arrhythmia mechanisms.
- The importance of radiation safety in terms of understanding deterministic and stochastic effects of fluoroscopy and the ALARA principle.

Skills:

- Ability to interpret the electrocardiogram tracings of a basic electrophysiological study.

Attitudes:

- Understanding the psychological impact of invasive arrhythmia treatment on young patients.

Cardiac implantable electrical devices

The trainee should acquire basic knowledge on cardiac implantable electrical device therapy in children and in adults with CHD.

They should know the indications and techniques for pacemaker, implantable cardiac defibrillator, and implantable loop recorder implantation and basics of cardiac implantable electrical device programming.

Knowledge:

- Understanding indications and implantation techniques for cardiac implantable electrical devices.
- Basic pacemaker/implantable cardiac defibrillator programming – sensitivity, voltage, mode, rate, AV delay.
- Recognition of the paced electrocardiography.

Skills:

- Ability to interrogate a cardiac implantable electrical device and programme the basic pacing parameters.
- Recognition of infectious complications after cardiac implantable electrical device implantation.
- Recognising the presence of pacemaker malfunction on electrocardiography.

Attitudes:

- Understanding the psychological impact of cardiac implantable electrical device therapy on young patients.
- Aim for close collaboration with electrophysiologists in cardiac implantable electrical device-related problems.

Inherited arrhythmia syndromes

Genetic testing and genetic counselling have evolved as an essential part of the diagnosis and management of inherited cardiac conditions. While genetic testing is clinically available for many of these conditions, it may not only identify clearly pathogenic causal variations in disease susceptibility genes but also genetic variants of uncertain clinical significance that may be difficult to interpret by the consulting physician. Genetic counselling should be delivered in cooperation with a specialised cardiac geneticist.

Knowledge:

- Understanding the conditions giving rise to channelopathies and cardiomyopathies.
- The role of genetic testing in suspected inheritable arrhythmia syndromes.
- Prognosis and management of the common inheritable arrhythmia syndromes.

Skills:

- Recognising the common electrocardiography signs of specific arrhythmia syndromes.
- Ability to plan and execute diagnostic genetic cascade screening in the family of an index patient.

Attitudes:

- Understanding the psychological impact of inherited arrhythmia syndromes on young patients and their families.
- Readiness for close collaboration with geneticists and electrophysiologists in diagnostics and management of patients with inherited arrhythmia syndromes.

Arrhythmias in adult CHD

Arrhythmias are an important cause for morbidity and mortality in adult patients with CHD. The population of adult CHD patients is increasing and with age there is an increasing burden of arrhythmias which are often complex. The trainee should understand how the modified post-operative intracardiac anatomy causes arrhythmia substrates in various CHDs.

Knowledge:

- The effects of cardiac surgery in producing arrhythmia substrates.
- The specific congenital defects associated with arrhythmias.
- The risk of sudden death in different conditions.
- Diagnosis and acute management of adult CHD patients presenting with arrhythmias.
- Understanding the challenges in electrocardiography diagnosis of arrhythmias in post-operative CHD.

Skills:

- Recognising intra-atrial re-entry tachycardia in the electrocardiography.
- Ability to plan and execute acute management of arrhythmias in adult CHD patients.
- Recognising underlying residual haemodynamic lesions predisposing for arrhythmias.

Attitudes:

- Close cooperation with electrophysiologists, interventionalists, and adult CHD physicians in the management of patients with arrhythmias.

Intensive care

The trainee should acquire experience in the daily activity of a paediatric cardiac ICU including invasive techniques applied in daily patient care. It is also recommended to spend ample time in the cardiac operating theatre in order to learn the basics of cardiopulmonary bypass and to be aware of the different surgical techniques.²

Knowledge:

- Neonatal circulation, transition to extra-uterine circulation, and its impact on clinical management of critically ill neonates with cardiac disease.
- Basics of intensive care management of most common congenital and acquired heart diseases from neonates to adults in the pre- and post-operative as well as post-interventional setting.
- Principles of invasive and non-invasive cardiac monitoring (non-invasive blood pressure, electrocardiography, oximetry, capnography, arterial lines, venous central lines, intra-cardiac lines (including right atrial, left atrial, pulmonary artery lines), Swan–Ganz catheter, emerging technologies).
- Evaluation and treatment of common neonatal cardio-circulatory disturbances in the absence of cardiac defects (i.e., persistent ductus arteriosus of the premature newborn, increased pulmonary vascular resistances secondary to persistent fetal circulation).
- Evaluation and treatment of common cardio-circulatory disturbances in infants and adolescents in the absence of cardiac defects (i.e., cardiac dysfunction in septic shock, trauma, metabolic diseases).
- Currently used scores of severity in the ICU/heart surgery arena (i.e., STAT, RACHS, Aristotle, PRISM).
- Basics on pharmacokinetics and use of cardiovascular drugs (i.e., dopamine, dobutamine, isoprenaline, adrenaline, noradrenaline, levosimendan, phenylephrine, calcium chloride, vasopressin, sodium nitroprusside, nitroglycerine, nicardipine, hydralazine, phentolamine, phenoxybenzamine, beta-blockers, and anti-arrhythmic drugs), including the management of their side-effects and interactions.

- Basics on pharmacokinetics and use of pulmonary vasodilator drugs (i.e., oxygen, inhaled nitric oxide, sildenafil, and prostacyclin).
- Basics on pharmacokinetics and use of inodilators (i.e., milrinone and enoximone).
- Use of prostaglandins E1, anti-coagulants, diuretics, and the management of their side-effects and interactions.
- Deep understanding of physiology: focussing in cardiovascular physiology, principles of mechanical ventilation, and cardiopulmonary interactions.
- Basic notions of cardiac anaesthesia.
- Basic notions of cardio-pulmonary-bypass, normo- versus hypothermia, deep hypothermia circulatory arrest.
- Basic notions on extra corporal membrane oxygenation, especially in the post-procedural setting aiming for bridge to recovery.
- Basic notions on assessment and management of sedation, anxiety, and pain.
- Basic notions on mechanical ventilation.
- Basic notions on nursing care and algorithms.
- Basic notions on nutrition of the critically ill cardiac patient.
- Basic notions of cardiac and non-cardiac complications of cardiac surgery (renal, neurological, respiratory, haematological, gastrointestinal, infectious).
- Basic notions on renal replacement therapy (peritoneal dialysis and haemofiltration).
- Development of a philosophy of care and promotion of multidisciplinary team work.
- Acquisition of Paediatric Advanced Life Support, Advanced Cardiovascular Life Support, and Basic Life Support accreditation, including cognitive and skills evaluation.
- Basic notions on neurological monitoring with cerebral near infra-red spectroscopy.

Skills:

The ability to:

- perform Paediatric Advanced Life Support and Advanced Cardiovascular Life Support and manage the patient in the post-resuscitation period.
- develop a structured approach to identify, manage, and stabilise the patient with haemodynamic instability.
- use emergency monitoring equipment and to timely identify cardiovascular abnormalities requiring urgent intervention.
- use non-invasive tools like echocardiography and Doppler to manage critical ill patients.
- participate in the decisions to admit, discharge, or transfer patients from the ICU.
- give cardiovascular system support:
 - perform arterial and central venous catheterisation.
 - 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.
 - perform pericardiocentesis.
 - treat and manage basic and complex arrhythmias in the acute care patient.
 - select and use fluids, inotropic, vasoactive, and anti-arrhythmic drugs.
 - use of external pacemakers (external pads, epicardial leads, trans-thoracic pacing).
- give 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).

Attitudes:

- Communicate, collaborate, and team work with the health care team (ICU nurses, ICU cardiologists, intensivists, and other staff).

Fetal cardiology

The trainee should become familiar with the present knowledge concerning fetal cardiology. The basic training level is recommended for all paediatric cardiology trainees.⁵ A close cooperation between the obstetrician or fetomaternal specialist and fetal cardiologist is crucial for optimal perinatal management.⁵ The trainee should be familiar with the screening scan in low-risk pregnancies at around 18–22 weeks of gestation as well as with the first trimester screening using the recognition of the increased nuchal translucency, abnormal ductus venosus flow, and tricuspid regurgitation in the evaluation of an increased risk of CHDs.¹³ The performance of an early anomaly scan in high-risk pregnancies is gaining importance.¹⁴ The trainee should be involved together with the obstetrician or fetomaternal specialist to distinguish between the normal and abnormal cardiac status and establishing the primary diagnosis. Together with the specialist in fetal cardiology, the trainee should be involved in making the final diagnosis and counselling of the parents. The paediatric cardiologist should be able to interpret a fetal cardiac exam performed by a sonographer/other person and interpret the report, as well as have an understanding of the adequate care that the baby will require after birth. It is not necessary to perform the fetal echocardiogram by himself/herself.

Knowledge:

- Physiology of the fetal cardiovascular system:
 - fetal circulation: importance of the essential shunts: foramen ovale, ductus venosus, ductus arteriosus.
- Fetal pathophysiology and cardiac function and how this differs from the postnatal physiology.
- CHDs dependent on one or more of the prenatal essential shunts and the postnatal management required.
- Transitional circulation in healthy fetuses and those with cardiovascular problems.
- Prenatal evolution of cardiac defects:
 - indications for prenatal cardiac interventions.
- CHDs and genetic problems:
 - indications to perform genetic testing.
 - current available genetic tests and their interpretation in cooperation with geneticists.
- Fetal arrhythmia:
- diagnosis of fetal tachycardia, bradycardia, and inappropriate heart rates in the fetus (recognition of abnormal M-mode and Doppler recordings).
 - indications of referral of a fetus with an arrhythmia to a fetal cardiologist for further diagnosis and management.

- indications and start of adequate prenatal treatment of a fetus with arrhythmia avoiding premature delivery.
- Fetal cardiac failure and cardiomyopathies:
 - differences between prenatal and postnatal causes.
 - application of the Cardiovascular Profile Score or similar scores to evaluate the fetal cardiovascular condition.
 - treatment options.
- Functional changes in the fetal cardiovascular system:
 - tricuspid regurgitation.
 - disproportion between right and left side of the heart.
 - regurgitation of the other cardiac valves (mitral, aortic, and pulmonary).
 - prenatal closure or restriction of the ductus arteriosus and/or foramen ovale
 - aetiology and consequences for the neonatal condition
 - perinatal management and treatment options.
- Fetal cardiovascular abnormalities due to maternal pathology (as diabetes, lupus, antiepileptic medications).
- Indications for fetal cardiac echocardiography and Doppler.
- Limitations of imaging, especially in the first trimester of pregnancies.¹³
- Legal regulations concerning termination the pregnancy in the specific country.

Skills:

The ability to:

- interpret and report a fetal cardiac exam performed by a sonographer or other person in order to detect cardiovascular problems in the fetus.
- detect warning signs when evaluating a fetal echocardiogram as size of the heart, fetal heart rhythm (abnormal four chamber, outflow tracts, mediastinal view), abnormal Doppler, and fetal hydrops.
- explain to the parents a (preliminary) diagnosis of the fetal cardiac problem and know when to refer them to the fetal cardiologist consultant.
- discuss with parents the possible prenatal treatment options (like transplacental treatment for arrhythmia).
- discuss prenatal cardiac interventions when needed – together with the fetal cardiologist consultant.
- predict the possible outcome (early and late prognosis) and potential progression of the lesion during gestation, including lethal anomalies, together with the other partners of the perinatal team.
- discuss the perinatal period and postnatal management including early and late outcomes if the final diagnosis is established.

Attitudes:

- Ability to communicate sensitively and with compassion.
- Ability to break bad news.
- Awareness of the value of the prenatal counselling and documentation for a good continuation of postnatal care.
- Communicate, collaborate, and team work with the health care team (obstetricians, feto-maternal specialists, geneticists, neonatologists, surgeons, and other staff).

3.8 Adult CHD

The remarkable improvement in survival of surgically and interventionally treated patients with CHD has led to an increasing number of adult CHD patients (former grown-up CHD).

For the trainee in general paediatric and congenital cardiology, it is necessary to know about the basic principles of CHD and the long-term outcome of the different lesions. Cooperation with other medical specialists (more or less the entire spectrum of adult medicine) will be utmost important.⁸

Knowledge:

- The natural history of CHD, of surgical and interventional treatment (palliative and repair) and post-interventional course (residua and sequelae, long-term outcome, long-term complications).
- The optimal timing and indications for interventions (surgical and catheter) in unrepaired and repaired lesions.
- The role of non-invasive imaging techniques.
- The role of haemodynamics and when to derive them invasively. Specificities of interventional therapy in adult CHD (balloon valvotomy, valve implantation, closure of shunt lesions, balloon dilatation and stenting of obstructive arterial and venous obstructions, occlusion of vessels).
- Surgical treatment strategies in adult CHD (palliative, reparative, corrective, transplantation) and perioperative management.
- The basics about psychosocial aspects, typical cardiovascular risk assessment, and influence of lifestyle – as physical activity, sports, contraception.
- Risk assessment of pregnancy in adult CHD and management during pregnancy, labour, delivery, and postpartum.
- The basics of clinical genetics for counselling.
- The need for vocational counselling and the obstacles encountered when obtaining insurances and driving license.
- The anatomical and functional complexity grade and their impact on patient management.
- Sufficient knowledge about transfer and transition from paediatric to adult CHD service.
- Sufficient knowledge about advanced care planning in adult CHD: transitioning from repair to palliation and end-of-life care.¹⁵
- Acquired cardiovascular disease (atherosclerosis, degenerative valvular heart disease, systemic hypertension, etc.) and its prevention, diagnosis, and treatment.
- Accompanying internal disease (pulmonary, renal, hepatic, etc.).
- Risk assessment of non-cardiac surgery in adult CHD and perioperative management.

Skills:

- Physical examination of adult CHD (specific presentation of CHD during adult life).
- Interpretation of the diagnostic procedures in adult CHD.
- Electrocardiography, exercise electrocardiography, cardiopulmonary exercise testing, and 24-hour Holter electrocardiography or longer time monitoring in adult CHD.
- Imaging techniques in the pre- and post-operative morphologic and functional assessment of adult CHD (echocardiography, MRI, multi-slice computed tomography, nuclear imaging) and their advantages in multimodality imaging.
- Interpretation of haemodynamic and angiographic findings from cardiac catheterisation in adult CHD.
- Diagnosis and treatment of heart failure in adult CHD (taking into account the difference between CHD and acquired heart disease).
- Correct diagnosis and adequate treatment of pulmonary hypertension in adult CHD.
- Diagnosis, drug treatment, and interventional treatment of arrhythmias in adult CHD (pathophysiology, non-invasive

diagnosis, invasive diagnosis, drug therapy, electrical, and interventional therapy (cardioversion, transitory stimulation, pacemakers, resynchronisation therapy, implantable cardiac defibrillators, catheter ablation)).

Attitudes:

- Ability to communicate sensitively and with compassion.
- Ability to shift communication more and more from parents to the patient and later to patients' direct familial environment.
- Ability to break bad news.
- Communicate, collaborate, and teamwork with the health care team (cardiologists and their sub-specialties, radiologists, cardiac surgeons, obstetricians, geneticist, and other staff).

Paediatric pulmonary hypertension

Pulmonary hypertension is a frequently occurring complication in CHD. Furthermore, patients with pulmonary hypertension will often be referred to cardiologists or pulmonologists for assessment. It is therefore important that all paediatric cardiology training programmes cover the basic training requirements that are recommended for all paediatric cardiology trainees, as stated in detail in the recommendations of the specific Association for European Paediatric and Congenital Cardiology WG.⁴

Knowledge:

- Signs and symptoms of pulmonary hypertension in children and its differential diagnoses.
- Understanding of the pathophysiology of pulmonary hypertension and knowledge of the different aetiologies and subgroups.
- Basic notions of the principles of pulmonary hypertension-targeted therapies (acute, chronic, and decompensated) as diuretics, anticoagulation, pulmonary vasodilators.
- Comprehension of the significance of elevated pulmonary vascular resistance in patients with CHD, reversibility, and its relevance in terms of indication/contraindication for surgical repair of CHD.

Skills:

The ability to:

- diagnose pulmonary hypertension in patients presenting with symptoms or in asymptomatic patients from high-risk populations.
- perform an echocardiographic assessment of pulmonary hypertension including diagnosis, physiology, shunts, presence of important CHD, assessment of afterload, and ventricular function.
- perform the initial evaluation and stabilisation of a haemodynamically compromised patient with pulmonary hypertension and initiate an appropriate supportive management.

Attitudes:

- Ability to communicate sensitively and with compassion.
- Ability to break bad news.
- Recognition of the importance of a multidisciplinary team in care for patients with pulmonary hypertension.

Heart failure and transplantation

General paediatric cardiology training should encompass knowledge and experience on diagnosis of patients with heart failure including a basic introduction to the care of patients with heart failure and post heart transplantation. The basic level is recommended for all paediatric cardiology trainees and should be available at all

centres/networks with a training programme in paediatric cardiology.³

Knowledge on heart failure:

- Understanding the pathophysiology and clinical presentation of the different types of heart failure that occur in acquired heart disease in children, genetic and familial cardiomyopathies, biventricular or univentricular CHD, with disease staging and initial differential approach in the diagnosis and treatment.
- Familiarity with available modalities for the diagnostic evaluation of children with newly discovered heart failure and the monitoring of chronic heart failure and role of diagnostic tests to establish an accurate diagnosis and subsequent management (B-type natriuretic peptide, genetic evaluation, metabolic assessment, cardiac imaging as electrocardiography, echocardiography, cardiac MRI, role of exercise testing, cardiac catheterisation, and endomyocardial biopsy).
- Understanding and interpretation of exercise tests, biomarkers, electrocardiography abnormalities, and haemodynamic parameters by cardiac catheterisation to plan the accurate treatment.
- Understanding the principles of medical management of heart failure (acute, chronic, decompensated), the role of the renin-angiotensin-aldosterone axis, the sympathetic nervous system and related treatment targets (ACE-inhibitors, AT2-antagonists, beta blockers, I_f-channel blockers, mineralocorticoid receptor antagonists, diuretics, and digitalis), and recognise the differences in metabolism and pharmacokinetics in paediatrics.
- Familiarity with identification and treatments of primary and secondary prevention of arrhythmias and thromboembolic complications.
- Understanding of additional therapies in the progression of heart failure including implantation of an implantable cardiac defibrillator, cardiac resynchronisation therapy, indications for mechanical circulatory support, and familiarity with clinical trials of novel therapies including stem cells.

Knowledge on cardiac transplantation and mechanical support:

- Indications of types of mechanical circulatory support in the treatment of end-stage heart failure and understanding the use of extracorporeal membrane oxygenation and ventricular assist devices as a bridge to transplantation or bridge to recovery or as destination therapy in selected cases.
- Indications and contraindications of heart transplantation.
- Basis of immunology, rejection, and human leucocyte antibody mismatch.
- Post-operative complications of heart transplant and physiology of the denervated, transplanted heart.
- Basics in immunosuppression agents and complications.
- Indications of ABO incompatible transplantation and complications.
- Recognition of heart transplant rejection, diagnostic tests, and basics of treatment.
- Outcome of heart transplantation, including mortality and morbidities during follow-up and indications of re-transplantation.
- The basics about complications associated with heart transplantation such as an acute and chronic rejection, coronary allograft vasculopathy, and sequelae of immunosuppression, such as infection, malignancy, and renal insufficiency.

Skills:

The ability to:

- detect warning clinical signs and symptoms of heart failure and interpret biomarkers.

- select and use diagnostic techniques to differentiate the underlying causes and precipitating factors of heart failure and to evaluate cardiac function and pulmonary pressures.
- perform echocardiographic assessment of heart failure including the presence of important CHD, assessment of afterload, and ventricular function.
- manage acute and chronic heart failure medically, recognise deterioration, and know-how to escalate treatment (refer to specialist service or for transplantation).
- educate patients and their relatives about self-care management and the importance of compliance to therapy in patients with heart failure or after heart transplantation.

Attitudes:

- Ability to communicate sensitively and with compassion.
- Ability to break bad news.
- Recognition of importance of multidisciplinary team (e.g., nurses, psychology) in care for children with end-stage heart failure.

Levels of multidisciplinary family-centred psychosocial care

General, non-disease-specific psychosocial interventions intended to decrease negative risk factors and strengthen protective factors in a family.¹⁶ Psychosocial care can be provided at three levels: the individual patient, the parents, and the family.⁶

The trainee is expected to be familiar with the basic principles of counselling. Additionally, the trainee is expected to be familiar with the normal development of a child from infant to young adult and the impact which this has on psychosocial care and communication with the patient and family. The influence hereof on the transition of the patient from paediatric to adult congenital cardiology should be respected.

Knowledge:

- Normal development of a child from infant to adult and factors that can interfere with this process.
- Possible psychosocial issues occurring during the lifespan for patients with CHD and their families.
- Psychosocial considerations of the teenage patients during transition and adequate communication style with this patient group.
- Effective communication strategies for an initial approach to psychosocial distress and effective referral to an adequate specialist available.
- Approach to quality of life and methods to assess a patient's and a family's quality of life.
- Different therapeutic strategies for psychotherapeutic treatment:
 - Psychosocial counselling and initiation of psychotherapeutic treatment at the level of the individual child/adult with chronic illness focussing on:
 - learning how to cope with physical limitations associated with the chronic condition.
 - learning to cope with negative emotions related with disease or medical procedures (anxiety, anger, sadness, despair, post-traumatic stress, hopelessness/or helplessness).
 - leaning to cope with a loss of control over one's own body and life.
 - Counselling of parents and initiation of psychotherapeutic treatment focussing on:
 - emotional issues (such as post-traumatic stress¹⁷ and fostering parenthood and parenting the CHD child).¹⁷⁻¹⁹

- providing support to parents regarding their social issues (such as arranging parental leave for cardiac surgery of the child, unemployment, financial problems).
- Counselling of families and initiation of psychotherapeutic treatment focussing on:
 - aims to gain insight in the inter-relationships within the family.
 - the impact of the chronic illness on each of the family members and the effect of stress on mutual relationships.
 - reducing the negative interactions and teach adequate problem-solving and coping strategies.

Skills:

- Be familiar with different styles of communication techniques.
- Recognise the multiple needs of the patient and family and be aware of the limitations of basic counselling and the need of professional support.
- Be able to organise a multidisciplinary approach with psychologists, social workers, and play therapists.
- Be able to consider the importance of adequate transition and transfer of patients to the adult clinic.
- Initiate the referral to local and international non-profit associations of patients and their families (such as the European Congenital Heart Disease Organisation) of patients and families when social issues are present.

Attitudes:

- Allow the patients and family members to express their anxiety and concerns when a CHD is diagnosed or when there is a change in the physical state of the patient.
- Allow the patients and family members to express their anxiety and concerns when undergoing interventional or surgical procedures.
- Be aware that psychosocial care from fetal to adult life is most effective when it is organised in a multidisciplinary setting. This includes collaboration with specialists as psychologists, social workers, and congenital cardiac specialist nurses.
- Be aware that communication shifts from “primarily with the parents” to “primarily with the patient” when the child grows older.
- Be aware that transfer to the adult clinic should be planned and prepared timely in order to prevent a care gap and potential loss to follow-up.
- Be aware that CHD can have a major impact on career and family planning and that these topics should already be addressed in adolescence.
- Collaborate with congenital, cardiac specialist nurses for communication, and psychosocial input to patients and their families from fetal to adult life.

Sports cardiology, physical activity, and prevention

The trainee should acquire experience in the assessment and treatment of heart disease risk factors in children and communicate strategies that help patients and families to follow a heart-healthy lifestyle. For patients with CHD, it is important to understand how exercise prescriptions can benefit them and to appropriately detect contraindications to exercise/competition.

Knowledge on prevention:

- Most common cardiovascular risk factors in childhood and adolescence, including the field of “fetal programming” of cardiovascular diseases.

- Cardiovascular risk factors specified for CHD patients, sedentary lifestyle, obesity, diabetes, arterial hypertension and arterial stiffness, dyslipidaemia, survival after oncological treatment, Kawasaki disease, and rheumatic diseases.
- The possibilities and limitations of genetic testing in the context of prevention and cardiovascular disease (e.g., predictive diagnostics, reverse cascade screening for familial hypercholesterolemia).
- Effects of physical activity, nutrition, education, and psychological risk factors on quality of life, exercise capacity, and cardiovascular risk.
- Gender-related reference values of body mass index, blood pressure, lipid status, and treatment of elevated values.
- Assessment of vascular risk status using tools to measure, for example, vascular stiffness, distensibility, and intima-media thickness.
- Prevention of sudden cardiac death in children (most common congenital arrhythmia syndromes).

Knowledge on sports cardiology for healthy young athletes:

- Exercise and sports physiology including benefits of exercise training.
- Pre-participation screening in young athletes stated in the Association for European Paediatric and Congenital Cardiology recommendations.²⁰
- Risk factors for mechanisms of sudden death during and after exercise.
- Electrocardiography evaluation and specific electrocardiography findings in athletes: recognising changes suggestive of primary electrical disease or cardiomyopathy (international criteria).^{21,22}
- Specific electrocardiography criteria and findings in the paediatric athlete.
- Echocardiographic findings in athletes' hearts including maturational changes of cardiac morphology and function in childhood.
- Cardio-pulmonary exercise testing (treadmill or bicycle ergometer) principles of performance, interpretation, and limitations in childhood.
- Principles in stress imaging in athletes and CHD patients (stress MRI, stress echo).
- Basics in nutritional aspects and drug side-effects in athletes.
- Ethical and legal basis of sport examinations (country specific).

Knowledge on sports cardiology for young athletes with CHD:

- Types of exercises and risks in CHD patients depending on their clinical situation and underlying disease (Bethesda criteria²³).
- Recommendations on physical activity in CHD patients.²⁴
- Specific issues of patients with electronic devices, cardiomyopathies, channelopathies, and/or an increased risk of acute cardiac events.
- Evaluation of exercise capacity and causes of exercise intolerance.
- Emergency care for patients during sport competitions.
- Basics of cardiac rehabilitation.
- Counselling of patients with CHD in sports issues.

Skills:

The ability to:

- perform an individual cardiovascular risk assessment using appropriate information from history including laboratory tests and clinical data in healthy children and CHD patients.

- perform a cardiovascular screening evaluation pre-participation in athletic activities in children and adolescents to prevent sudden death.
- perform a physical examination and evaluate physical activity in patients with CHD (and special consideration on disorders going along with cardiovascular risks: obesity, athletes, anorexia, hypertension, Marfan syndrome) and give adequate recommendations for participation in leisure time or competitive sports.
- perform and interpret a cardiopulmonary exercise test.
- recognise pathological cardiovascular changes and differentiate them from the "athlete's heart."
- prescribe exercise-based rehabilitation programmes and other lifestyle interventions in collaboration with other specialist, according to the CHD patient's condition.

Attitudes:

- Recognition of the role of an active lifestyle, exercise, and sport in the promotion of health and in the prevention of cardiovascular diseases.
- Recognition of the importance of patient and family education and the role of other professionals including nurse specialists, exercise physiologists, psychologists, dietitians, and paediatricians in cardiac rehabilitation.
- Recognition and advocating of medical guidance to promote safe training and a healthy development of the elite paediatric athlete.

Congenital cardiovascular surgery

The trainee should be involved in the collaboration with the cardiac surgeon concerning pre-operative diagnosis and decision-making and acquire the following knowledge:

Knowledge:

- Essential pre-operative information required to refer patients with CHD for cardiac surgery.
- Main surgical indications for large majority of CHD.
- Main surgical techniques for large majority of CHD.
- Be familiar with risk stratification and outcome analysis for surgical results.
- Typical complications in the short- and long-term follow-up after cardiovascular surgery.
- Different biological and artificial material used in congenital cardiovascular surgery as types of patches, valved and non-valved conduits and grafts, mechanical heart valves, and vascular prosthesis.
- General theoretical understanding of the cardiopulmonary bypass circuit and anaesthesia during congenital heart surgery.
- In depths theoretical understanding of surgical procedures.
- Basic notions on indications and performance of hybrid procedures in collaboration with the interventional cardiologist (i.e., hybrid hypoplastic left heart syndrome approach, ventricular septal defect closure with apical access, stenting of a coarctation in premature infants).

Skills:

The ability to:

- be able to discuss surgical indications and types of procedures according to the patient's clinical status and imaging records.
- interpret the surgical operation report.
- be able to assess anatomical and pathophysiological results of surgical repair/palliation in the early and late outcomes after surgery.

- judge the longer-term consequences and requirements of the post-operative situation.

Attitudes:

- Establish a close collaboration with the surgeons spanning from pre- to post-operative management.

Certification of completion of training

Training logbook

The logbook is a tool for the trainee and trainer to keep track of the progress of the trainee. It is the responsibility of the trainee to record all relevant activities. In countries where national guidelines exist, the trainee might maintain a national equivalent to the Association for European Paediatric and Congenital Cardiology logbook.

The logbook should be countersigned by the trainer confirming that the trainee has satisfactorily achieved the requirements stated according to these recommendations.

It is the responsibility of the trainer to audit and certify the activities. The trainee should also keep copies of certificates of attendance of Association for European Paediatric and Congenital Cardiology recommended and approved supplementing courses and add those to the logbook.

Annual appraisal and assessment

The trainer and/or the head of the department of each institute providing the complete training programme or part of it should carry out appraisals and assessments to evaluate (annually) the progresses of the trainee.

Final assessment

Ideally, the training should be completed by a final assessment. This could be by means of an exit examination or by continuous assessment of competencies during training. The assessment or examination should combine written, oral, and practical components.

Association for European Paediatric and Congenital Cardiology examination

The Association for European Paediatric and Congenital Cardiology is in the process of developing an Association for European Paediatric and Congenital Cardiology certification/diploma in paediatric and congenital cardiology.

Logbook and additional information

Criteria to get the diploma are based on the statement of the supervising trainer and the individual performance of the trainee. The major part is the presentation of the logbook stating the respective, individual performance.

The following documents are necessary:

- Proof of training written by the supervising trainer.
- Logbook documenting completion of required procedures.
- Involvement in one research project.
- Certificate of attendance of two national or international meetings in paediatric cardiology/congenital heart surgery.
- One published article and/or presentation on the abovementioned congresses.

Logbook of procedures

Purpose:

To ensure that the trainee has adequate exposure to a range of clinical procedures and techniques in preparation for physician practice.

Requirement:

A logbook showing details over the course of training and kept updated regularly throughout the training is essential. The trainee must maintain all performed clinical procedures including the information about the level of supervision in the logbook. Supervisors are required to confirm in their reports that the logbook is a true and accurate record of the trainee's experience and that all training requirements have been fulfilled.

Procedures/activity

- Ambulatory care:
 - Manage patients in an ambulatory care (outpatient) setting under supervision – minimum number: 200 patients.
- Cardiac catheterisation and balloon atrial septostomy:
 - Participate and report cardiac catheterisation and haemodynamics – minimum number: 50 cases including Rashkind balloon atrioseptostomy procedures.
- Direct current cardioversion:
 - Perform direct current cardioversion – minimum number: five cases.
- Echocardiograms:
 - Fetal echocardiograms (observation, not necessarily primary operator and associated counselling) – minimum number: 20 studies.
 - Transoesophageal echocardiograms – minimum number: 50 studies, 25 studies as a primary operator (all studies should be reviewed and have finalised consultant reports).
 - Transthoracic echocardiograms – minimum number: 500 cases, 300 under supervision of a paediatric echocardiographer/cardiologist and at least 400 on patients with cardiac pathology (all studies should be reviewed and have finalised consultant reports).
- Electrocardiograms:
 - Interpret and report electrocardiograms on both inpatients and outpatients – minimum number: 150 cases.
- Electrophysiology:
 - Participate in clinical decision-making for electrophysiology study/ablation procedure, including observation of procedures and interpretation of reports – minimum number: 10 cases.
- Exercise tests:
 - Supervise and report exercise tests – minimum number: 50 cases.
- Holter monitor:
 - Supervise and report Holter monitor – minimum number: 50 cases.
- Imaging:
 - Interpret chest X-rays – minimum number 100 cases.
 - Interpret results of cardiovascular magnetic resonance, thoracic CT, and radionuclide imaging – minimum number: 10 cases (in total).
- Pacemaker:
 - Observe pacemaker implantation – minimum number: five cases.

- Participate in testing permanent pacemaker function – minimum number: 20 cases.
- Perform pacemaker testing – minimum number: 20 cases.
- Pericardial aspiration:
 - Perform pericardial aspiration under supervision and demonstrate competency as an independent operator – minimum number: two cases.

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Conflicts of Interest. None.

Ethical Standards. Not applicable.

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