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Author for correspondence: Thomas Kriebel, MD, FEHRA, Department of Paediatrics and Paediatric Cardiology, Westpfalz-Klinikum Kaiserslautern, Hellmut-Hartert-Straße 1, 67655 Kaiserslautern, Germany.
Tel: +49 631 2031370; Fax: +49 631 2031782.
E-mail: tkriebe@gwdg.de

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Recommendations from the Association for European Paediatric and Congenital Cardiology for training in diagnostic and interventional electrophysiology

Thomas Kriebel[1], Eric Rosenthal[2], Roman Gebauer[3], Juha-Matti Happonen[4], Fabrizio Drago[5], Ulrich Krause[6], Nico A. Blom[7], Tomasz Książczyk[8] and Laszlo Kornyei[9]

[1]Department of Paediatrics and Paediatric Cardiology, Westpfalz-Klinikum, Kaiserslautern, Germany; [2]Department of Paediatric Cardiology, Evelina London Children's Hospital, London, UK; [3]Department of Paediatric Cardiology, Heart Center, University Hospital Leipzig, Leipzig, Germany; [4]Department of Paediatric Cardiology, Helsinki University Children's Hospital, Helsinki, Finland; [5]Department of Paediatric and Paediatric Surgery, Bambino Gesu Children's Hospital, Rome, Italy; [6]Department of Paediatric Cardiology and Intensive Care Medicine, Georg August University Medical Center, Göttingen, Germany; [7]Department of Pediatric Cardiology Leiden University Medical Center, Leiden, Amsterdam University Medical Center, Amsterdam, The Netherlands; [8]Department of Paediatric Cardiology and General Paediatrics, Medical University of Warsaw, Warsaw, Poland and [9]Gottsegen György Hungarian Institute of Cardiology, Hungarian Paediatric Heart Center, Budapest, Hungary

Abstract

The field of electrophysiology (EP) in paediatric cardiology patients and adults with congenital heart disease is complex and rapidly growing. The current recommendations for diagnostic and invasive electrophysiology of the working group for Cardiac Dysrhythmias and Electrophysiology of the Association for European Paediatric and Congenital Cardiology acknowledges the diveristy of European countries and centers. These training recommendations can be fulfilled in a manageable period of time, without compromising the quality of training required to become an expert in the field of paediatric and congenital EP and are for trainees undergoing or having completed accredited paediatric cardiologist fellowship. Three levels of expertise, the training for General paediatric cardiology EP, for non-invasive EP and invasive EP have been defined. This Association for European EP curriculum describes the theoretical and practicsal knowledge in clinical EP; catheter ablation, cardiac implantable electronic devices, inherited arrhythmias and arrhythmias in adults with congenital heart defects for the 3 levels of expertise.

At the 50th annual meeting of the Association for European Paediatric and Congenital Cardiology in Rome 2016, the Working Group for Cardiac Dysrhythmias and Electrophysiology of the Association for European Paediatric and Congenital Cardiology officially appointed a Task Force to develop training recommendations for diagnostic and invasive electrophysiology in paediatric cardiology and adults with CHD in Europe. Members of the Task Force included the current working group council, the working group junior representative, the Association for European Paediatric and Congenital Cardiology scientific secretary, and additional ordinary members to represent a wide range of training centres from different European countries. Each member of the Task Force is a recognised expert in the field of electrophysiology in paediatric cardiology and adults with CHD. The recommendations developed by the Task Force were approved at the official business meeting of the working group at the 52nd Association for European Paediatric and Congenital Cardiology annual meeting in Athens in 2018. The Task Force document was then approved by the Association for European Paediatric and Congenital Cardiology educational committee in 2020 as well as by the general Association for European Paediatric and Congenital Cardiology council.

The Association for European Paediatric and Congenital Cardiology represents not only members from all 47 European countries but from all 5 continents of the world. This includes large countries with high volume centres and smaller countries with only one small paediatric cardiology unit. Due to this diversity of countries and centres, specific European training recommendations were necessary despite existing US guidelines.[1–3] Acknowledging this diversity, the Task Force tried to develop recommendations that could be fulfilled in a manageable period of time, without compromising the quality of training required to become an expert in the field of electrophysiology. Thus, where necessary it is possible to fulfil the requirements at more than one centre and in more than one country. Given

the different structures in the different centres, cooperation between centres is inevitable and strongly encouraged to facilitate this.

All recommendations of this manuscript should be integrated with local and national recommendations (this could mean a country could have its own minimalist guidelines and then expect their trainee to be qualified in the rest of Europe). In addition, description of special arrhythmias, devices and drug therapy is beyond the scope of the present manuscript and has already been discussed elsewhere.[4] Finally, this manuscript describes the electrophysiology training recommendations for trainees undergoing or having completed accredited paediatric cardiologist fellowship and do not apply to trainees undergoing or having completed adult cardiology fellowship programmes.

Levels of expertise

The Task Force of the Association for European Paediatric and Congenital Cardiology Working Group for cardiac Dysrhythmia and Electrophysiology developed three different levels of expertise in the field of electrophysiology.

These are

- Electrophysiology curriculum for fellowship in general paediatric cardiology – all paediatric cardiology trainees (general paediatric cardiology electrophysiology training)
- Basic training level focusing on non-invasive paediatric and congenital electrophysiological skills (non-invasive electrophysiology training)
- Advanced training level including extensive knowledge and skills in invasive electrophysiology (invasive electrophysiology training)

In contrast to some adult guidelines separating invasive electrophysiology and device management and implantation, the Association for European Paediatric and Congenital Cardiology electrophysiology curriculum includes both entities. As the field of electrophysiology in paediatric cardiology patients and adults with CHD is complex, the Task Force acknowledges that full proficiency in all fields of electrophysiology, including device management, may only be achieved after completion of the training curriculum and that ongoing training may be required.

The writing group adopted the minimum theoretical skills as well as the volume of procedures for each level on the basis of personal experience and clinical practice, along with careful review of international guidelines (see below).

Electrophysiological skills required for fellows in general paediatric cardiology (general paediatric cardiology electrophysiology training)

The current Association for European Paediatric and Congenital Cardiology recommendations for general training in paediatric and congenital cardiology propose five modules during the 3 years of basic training: basic paediatric cardiology, imaging, haemodynamics and catheterisation, cardiac rhythm disorders, and paediatric intensive care.[5]

The general paediatric cardiology electrophysiology training requirements described in this section are intended to be sufficient for fellows who do not plan a formal career in electrophysiology. Training is required for all trainees and is intended to ensure that each fellow acquires the knowledge base and skills necessary to become a paediatric cardiologist. However, in patients with (complex) electrophysiological problems, the general paediatric cardiologist should discuss or refer his/her patient for more detailed and sometimes invasive rhythm investigation to a certified paediatric electrophysiology specialist.

Non-invasive electrophysiology training: goals and methods

Non-invasive paediatric and congenital electrophysiology training requirements are designed for fellows who have special interest in paediatric arrhythmias and wish to embark on a career as non-invasive rhythmologist/electrophysiologist or wish to take the first step to become an invasive electrophysiologist. By the completion of basic paediatric and congenital electrophysiology training, the trainee should be able to achieve high-level competency in all clinical aspects of non-invasive electrophysiology and should become proficient in the care of arrhythmias in the fetus, infant, child, and adolescent as well as in adults with CHD. The minimum amount of practical procedures recommended for the non-invasive paediatric and congenital electrophysiology training may be fulfilled during the general paediatric cardiology training or after. Procedures should be signed off (in a logbook) by the programme director or deputy.

At least one electrophysiological research project suitable for publication in a peer-reviewed journal is recommended. This research project should be in an advanced state at the time of certification.

Attendance at the arrhythmia course of the Association for European Paediatric and Congenital Cardiology Working Group for Cardiac Dysrhythmias and Electrophysiology, at least once, is mandatory for trainees at the basic level. Attendance at other national or international arrhythmia meetings is also strongly encouraged and should be logged.

Paediatric electrophysiology qualification (the Association for European Paediatric and Congenital Cardiology/European Heart Rhythm Association test, or alternatively the IBHRE (International Board of Heart Rhythm Examiners) exam until 2023 – see below) is required before certification as a non-invasive and invasive paediatric and congenital electrophysiology specialist.

Finally, it is possible that at the end of the general paediatric training, the non-ivasive level of electrophysiology training can be achieved, as there is no minimum time required for the non-invasive training.

Invasive electrophysiology training: goals and methods

The aim of the advanced level of training is to equip paediatric electrophysiologists with the theoretical background as well as technical skills to be able to manage all forms of rhythm disorders. In addition to fulfilling all aspects of non-invasive electrophysiology, an intensive training in invasive procedures such as electrophysiological studies, catheter ablation, including the use of modern 3D-mapping systems, and device implantation is required. Particular emphasis should be given to diminishing the radiation exposure of the patient as well as the operator, by striving for minimally fluoroscopic and non-fluoroscopic techniques. During the training period, the use of simulator training to facilitate manual skills is encouraged despite the lack of its wide spread availability at the present.

The field of paediatric and congenital electrophysiology is vast and rapidly developing. Therefore, paediatric electrophysiologists will need to continue their training in certain fields after certification at the advanced level in their substantive post. In addition, ongoing training could occur after completion of general cardiology fellowship where there are excellent mentors who could continue to assist in both procedural cases and complex arrhythmia

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and device management. This ongoing training does not necessarily have to be a formal fellowship but could occur during the individual's first substantive post.

Practical skills already achieved and additional numbers of procedures required during the general paediatric cardiology training, or during the non-invasive training, will be taken into account. At least 30% of the procedures should be performed in children <30 kg to fulfil this level.

At least one electrophysiological research project suitable for publication in a peer-reviewed journal is recommended. This research project should be in an advanced state at the time of certification.

The minimum time of training for the advanced level is 2 years after completion of general paediatric cardiology training in a certified centre (see below).

The written Association for European Paediatric and Congenital Cardiology/European Heart Rhythm Association test (or alternatively the IBHRE exam until 2023 – see below) must be obtained prior to certification. Certification of the invasive level is possible 2 years after general paediatric cardiology training, if all requirements for non-invasive and invasive training (practical skills, courses, and written electrophysiology exam) are fulfilled.

Cooperation with adult electrophysiology programmes

It is preferred that training will primarily occur in centres treating paediatric and adults with CHD patients. At present only a few paediatric and congenital electrophysiology training programmes in Europe have sufficient numbers of complex ablation and implantation procedures of cardiac implantable electronic devices, to fulfil the recommended numbers of procedures in an acceptable time span. In contrast to this, the volume of electrophysiology procedures is significantly higher in the adult electrophysiology laboratory. In addition, some specific procedures (e.g., atrial fibrillation, complex ablation of ventricular tachycardia) are not common in the paediatric setting. Therefore, a minimum period of 3 months of training in an adult electrophysiology laboratory is recommended. During this time, the trainee should concentrate on electrophysiology in adult patients with CHD.

While additional general electrophysiology expertise may be obtained by working in an adult laboratory, it is recommended that no more than 6 months should be accredited to the overall paediatric and congenital electrophysiology training programme. Additional time, however, after completion of advanced training and also after appointment to a substantive post is encouraged to keep abreast of advances in the field.

The director of the adult training programme should fulfil the requirements of the European Heart Rhythm Association, or an equal national programme, for leading an adult electrophysiology centre and should be certified by the European Heart Rhythm Association or national committee. If the trainee works in a combined paediatric/adult electrophysiology laboratory, the focus should be on procedures performed in paediatric and adult patients with CHD. In these laboratory settings, the paediatric director should, in addition to the requirements of the adult director (see above), be qualified according to these recommendations.

Requirements for training centres

The training centre should be accredited as a centre for a full fellowship programme in paediatric cardiology by the local/national authorities or by the Association for European Paediatric and Congenital Cardiology. In-patient as well as outpatient treatment must be available at the training centres. The centre must have a paediatrician and a paediatric cardiologist onsite or on call 24 hours a day. In addition, a heart surgery programme, an accredited programme for adults with CHD (if this accreditation is available in the specific country), and an interventional paediatric cardiac catheterisation programme should be available. The catheterisation laboratory must be equipped in accordance with the Association for European Paediatric and Congenital Cardiology recommendations.[6] In stand-alone paediatric cardiac centres, cooperation with a centre caring for adults with CHD is essential. In addition, the institution should have strong links to adult electrophysiology. All centres must have high-quality facilities as well as qualified support staff for performing electrophysiology studies, catheter ablation, and device implantation. In addition, the procedure volume for electrophysiology testing and ablation should be large enough to meet the criteria for the advanced level in 2 years. However, extra time will be allowed but should be minimised. Cooperation with other paediatric and adult electrophysiology centres may be needed to meet the required volume of procedures. It is also possible for two centres to apply as one training centre if both centres cannot meet the above-mentioned criteria alone.

The electrophysiology laboratory should be equipped with biplane fluoroscopy, a modern multichannel electrogram recording system, a stimulator for programmed stimulation, and a defibrillator. Radiofrequency energy, including irrigated tip technology as well as cryoenergy, should be available. At least one 3D-electrophysiology mapping system should be available in the laboratory and at least two staff members should be trained to use it.

A trained allied professional able to assist with device interrogation should be part of the team. For the electrophysiology laboratory, a 24-hour on-call catheter nurse as well as a catheter technician should be available.

Anaesthetists with experience in paediatric and CHD patients are essential.

Director of the electrophysiology programme

The director of the electrophysiology programme should be a paediatric cardiologist acknowledged as an experienced paediatric electrophysiologist who is certified in the advanced training level of the Association for European Paediatric and Congenital Cardiology electrophysiology training recommendations. The director is responsible for the curriculum, directing the non-invasive and invasive procedures as well as scientific activity of the trainee. Regular meetings with the trainee should be performed at a minimum of 6 monthly intervals and these should be logged in the trainees' book.

From 2023 onwards, any new programme director who is not already an experienced and acknowledged paediatric electrophysiologist must have completed a written electrophysiology examination as above. All directors must be accredited by the Association for European Paediatric and Congenital Cardiology electrophysiology working group council.

Requirements for each level of expertise in special aspects

Clinical electrophysiology

Clinical electrophysiology is the basis of the subspecialty. Trainees at all three levels should acquire knowledge concerning clinical symptoms, diagnosis, and management of common paediatric arrhythmias. Evaluation of arrhythmia symptoms and skills in electrocardiogram differential diagnosis of common

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supraventricular dysrhythmias are essential. All trainees should acquire expertise in the acute pharmacological management of children with arrhythmia and attend paediatric outpatient clinics to obtain competence in arrhythmia management and chronic antiarrhythmic drug treatment. Differentiation of postural orthostatic tachycardia syndrome and inappropriate sinus tachycardia syndrome from other forms of tachycardia is expected from trainees at every level.

Beyond the general statement mentioned above, the general paediatric cardiologist should know the special paediatric dosages and side effects of drugs used for common supraventricular tachycardias. General paediatric cardiologist should know the aetiology of paediatric ventricular arrhythmias and recognise the common benign forms. Aetiology, evaluation, therapy, and prognosis of atrioventricular conduction block should be part of the training already at this level. Decisions about prenatal diagnosis and treatment can be left for advanced paediatric rhythmologist for all kind of fetal arrhythmias, but knowledge on theoretical potentials and limitations of fetal diagnosis and treatment can be expected. The paediatric cardiologist should be able to confirm the suspicion of cardiac syncope, even if provoking tests can be left for basic rhythmologists. Scientific background, theoretical limitations, and cost efficacy of general electrocardiogram screening is that part of rhythmology which is indispensable even for paediatric cardiology training. As healthy lifestyle has become very popular in public thinking, the role of sport activity in preservation of health and its role in provocation of sudden cardiac death should be reflected already during general paediatric cardiology training. All trainees should be competent in interpretation of standard electrocardiogram, ambulatory (Holter) electrocardiogram, exercise electrocardiogram, and transtelephonic electrocardiogram. External cardioversion and defibrillation is part of emergency care and paediatric cardiology trainees should acquire these skills already at the beginning of their career. The trainees should be aware of the psychological impact in patients undergoing pharmacological and invasive antiarrhythmic therapy.

Specific requirements for general paediatric cardiology:

- Electrocardiogram – understand 12 lead, ambulatory, exercise, event recorders;
- Types of supraventricular tachycardia, recognition and treatment, doses and side effects of medication;
- Aetiology of ventricular tachycardia, distinguish between benign and malignant types;
- Heart block – aetiology, evaluation, management, and prognosis;
- Use of temporary pacing wires in the diagnosis and treatment of post-operative arrhythmias;
- Use of an oesophageal electrode in the differential diagnosis of arrhythmias;
- Fetal arrhythmias – theoretical potential and limitations;
- Electrocardiogram screening – background, limitations, and cost-effectiveness;
- Sport – screening, role in sudden death;
- Cardioversion;
- Syncope – evaluation and distinction between benign and malignant types by non-invasive assessment.

Specific requirements for non-invasive electrophysiology training:

- All items mentioned above, and;
- Antiarrhythmic medication – use of drug combinations and their potential side effects; use of antiarrhythmic drugs in special populations (CHD, cardiomyopathies, and channelopathies);
- Ventricular tachycardia – non-invasive evaluation;
- Indications for catheter ablation and cardiac implantable electronic device implantation. Knowledge of the techniques, complications, and limitations of these procedures;
- Heart block – pacemaker follow-up, pacemaker-induced cardiomyopathy, and role of resynchronisation;
- Fetal arrhythmias – planning management, medication, and delivery with the fetal team;
- Inherited arrhythmias – provocative drug testing;
- Knowledge of international guidelines regarding the recommendations of sport activity in patients with arrhythmia;
- Syncope – use of implantable loop recorders;
- Therapeutic education for patient and family.

Specific requirements for invasive electrophysiology training

- All items mentioned in the two sections above, and;
- Drug-resistant arrhythmia management – role of transcatheter ablation;
- Ventricular tachycardia – role of transcatheter ablation in various clinical settings.

For specific numbers regarding the practical skills at different levels, see Table 1.

Catheter ablation

Transcatheter ablation in paediatrics should be focused on the needs of children. In particular, it is important to educate the paediatric electrophysiology trainees to put into practice a correct clinical, diagnostic, and therapeutic process before and after procedural intervention.

The trainee and trainer should be more focused on accuracy, efficacy, and safety than on the number of procedures performed.

Requirements for general paediatric cardiology:

- Understand mechanisms of arrhythmias;
- Indications for transcatheter ablation;
- Radiation safety – ALARA.

Requirements for non-invasive electrophysiology training:

- All of the above, and;
- Basic EP study skills including:
  - Vascular access;
  - Electrode positioning;
  - Intracardiac signals;
  - Intracardiac stimulation;
- Diagnosis of arrhythmia mechanism based on the electrophysiology study;
- Principles of 3D-mapping, radiofrequency ablation, irrigated catheter ablation, and cryoablation;
- Thorough knowledge of biological effects of radiation, radiation protection measures, ALARA principle, minimal or non-fluoroscopic techniques.

Requirements for advanced electrophysiologist training:

- All items mentioned in the two sections above, and;
- Understand mechanisms of arrhythmias including rare substrates;
- Understand the use of transcatheter ablation in various populations (neonates, infants, CHD, and adults with CHD);
- Thorough knowledge of catheter ablation techniques, and available ablation energy sources;
- Role of unusual approaches – transhepatic, epicardial;
- Perform electrophysiology studies and catheter ablation independently including use of at least one 3D electroanatomic mapping system.

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Table 1. Recommendations for theoretical and practical knowledge for the general paediatric training as well as basic and advanced training in paediatric electrophysiology

Clinical field	General paediatric cardiologist	Non-invasive paediatric electrophysiologist	Invasive paediatric electrophysiologist
1. Clinical electrophysiology		*Theoretical*	
Mechanism of common paediatric arrhythmias	+	+	+
Basics of arrhythmia diagnosis	+	+	+
Basics of arrhythmia therapy DC shock, AAD,TCA,CIED	+	+	+
Clinical symptoms of paediatric arrhythmias	+	+	+
Evaluation of palpitations	+	+	+
Postural orthostatic tachycardia syndrome	+	+	+
Evaluation common paediatric SVTs	+	+	+
Antiarrhythmic drug therapy of paediatric SVTs			
Common, single-drug therapy	+	+	+
Risks of drug combination, adverse events	+	+	+
Indication for rescue ablation	–	–	+
VT and PVCs			
Differentiation between malignant and benign forms	+	+	+
Non-invasive evaluation	–	+	+
Invasive evaluation	–	–	+
AV block			
Postnatal diagnosis + therapy	+	+	+
Prenatal diagnosis + therapy + follow-up	–	+	+
Prevention and recognition of PM-induced cardiomyopathy	–	+	+
Therapy of PM-induced cardiomyopathy	–	+	+
Fetal arrhythmias + management			
Potentials + limitations	+	+	+
Understanding fetal echo findings	–	+	+
Active participation in multi-speciality team	–	+	+
Syncope			
Recognition of cardiac syncope	+	+	+
Non-invasive evaluation	+	+	+
Provocative tests	–	+	+
Indication for ILR	–	+	+
ECG screening for sudden cardiac death			
Theoretical limitations	+	+	+
ECG signs of IAS	+	+	+
Provocative tests	–	+	+
Sport and arrhythmias			
Role of sport activity in provocation of SCD	+	+	+
Recommendations for leisure and competitive sports	–	+	+
Interpretation of EP study measurements	–	+	+
		Practical	
ECG	150	1000	1000
Holter	50	100	300

(*Continued*)

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Table 1. (*Continued*)

Clinical field	General paediatric cardiologist	Non-invasive paediatric electrophysiologist	Invasive paediatric electrophysiologist
Exercise test	10	30	30
EP study with or without ablation	10	50	50
ILR	–	–	10
External cardioversions	5	5	10
Acute and chronic medical management of arrhythmia in children and patients with CHD (inpatient and outpatient)	50	200	200
2. Catheter ablation		*Theoretical*	
Basic knowledge of radiation safety and ALARA concept	+	+	+
Indication in children	+	+	+
Technology and techniques	–	+	+
SVT ablation	–	+	+
VT ablation	–	+	+
IART ablation	–	+	+
Epicardial ablation	–	+	+
Special situations (neonatal, JET, PJRT, Mahaim ...)	–	+	+
		Practical	
EP study with ablation		–	150
3. Cardiac implantable electronic devices		*Theoretical*	
PM therapy of AV block (indication)	+	+	+
Epicardial versus endocardial	–	+	+
Stimulation modes	+	+	+
Complications of PM therapy	+	+	+
Pacing and heart failure	–	+	+
PM-induced CM and CRT	–	+	+
ICD therapy (indication)	+	+	+
Endocardial versus subcutaneous	–	+	+
Complications of ICD therapy	+	+	+
Cardiac MRI with CIED	–	+	+
		Practical	
Interrogation/programming of pacemakers/ICD/CRT systems, including intraoperative testing, control of pacemaker/ICD during MRI procedures	–	100	100
Post-operative epicardial programming/oesophageal study	–	5	10
Implantation procedures (including: assist epicardial pacemaker/ICD implantation; implant transvenous PM/ICD/CRT systems, lead extractions	–	–	50
4. Inherited arrhythmias		*Theoretical*	
Basics of genetics/genetic screening	+	+	+
Diagnosis of IAS	+	+	+
Pharmacological therapy in IAS	–	+	+
Non-pharmacological therapy in IAS	–	+	+
Diagnosis of ICM	+	+	+
Pharmacological therapy in ICM	–	+	+
Non-pharmacological therapy in ICM	–	+	+

(*Continued*)

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Table 1. (*Continued*)

Clinical field	General paediatric cardiologist	Non-invasive paediatric electrophysiologist	Invasive paediatric electrophysiologist
		Practical	
Interpretation of genetic test result and genetic counselling		5	50
5. Arrhythmias in adults with CHD		*Theoretical*	
Impact of cardiac surgery on arrhythmogenesis and treatment, predisposing factors for arrhythmias in adults with CHD	+	+	+
Prevalence and prevention possibilities	+	+	+
Diagnostic challenges and acute management	+	+	+
Chronic therapeutic options	–	+	+
Pharmacological therapy	–	+	+
Non-pharmacological therapy (catheter ablation/device/surgical)	–	+	+
Risk stratification for sudden cardiac death	–	+	+
Device therapy for the prevention of SCD	–	+	+
Effect of pregnancy on arrhythmia risk	–	+	+
Special aspects of atrial fibrillation in adults with CHD	–	+	+
		Practical	
Acute and chronic medical management of arrhythmia in adults with CHD (inpatient and outpatient)	–	10	50
EP study with ablation	–	–	20

AAD = antiarrhythmic drugs; AV = atrioventricular; CIED = cardiac implantable electronic device; CM = cardiomyopathy; CRT = cardiac resynchronisation therapy; DC = direct current shock; ECG = electrocardiogram; EP = electrophysiology; IART = intraatrial reentrant tachycardia; IAS = inheritable arrhythmia syndromes; ICD = implantable cardioverter defibrillator; ICM = inheritable cardiomyopathies; ILR = implantable loop recorder; JET = junctional ectopic tachycardia; PJRT = permanent junctional reentrant tachycardia; PM = pacemaker; PVC = premature ventricular complex; SCD = sudden cardiac death; SVT = supraventricular tachycardia; TCA = catheter ablation; VT = ventricular tachycardia

For specific numbers regarding the practical skills at different levels, see Table 1.

Cardiac implantable electronic devices

Requirements for general paediatric cardiology:

- Understand indications and implantation techniques for cardiac implantable electronic devices;
- Basic pacemaker/implantable cardiac defibrillator programming – mode, rate, AV delay;
- Recognition of the paced electrocardiogram.

Requirements for non-invasive electrophysiology training:

- All items above, and;
- Understand difference between epicardial and endocardial pacing and choosing appropriate technique;
- Awareness of all possible complications of cardiac implantable electronic devices;
- Understand effect of pacing at different sites in the heart and pacing-induced cardiomyopathy;
- Pacemaker/implantable cardioverter defibrillator follow-up, programming, and troubleshooting should be performed independently.

Requirements for invasive electrophysiology training:

- Thorough knowledge of cardiac implantable electronic device implantation techniques and the potential complications (pacemaker, cardiac resynchronisation therapy, implantable cardioverter defibrillator, and implantable loop recorder);
- Implantation of pacemakers and implantable cardioverter defibrillator independently;
- Understand the role of cardiac resynchronisation therapy in various situations and cardiac anatomies;
- Understand defibrillation testing;
- Knowledge of indications for lead extraction; lead extraction techniques and their potential complications.

For specific numbers regarding the practical skills at different levels, see Table 1.

Inherited arrhythmias

Genetic testing and genetic counselling evolved as an essential part of the diagnosis and management of inherited cardiac conditions.[7,8] 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.[9] Due to the low familiarity of paediatric cardiologists/electrophysiologists in this evolving field, it is essential that the indication for and interpretation of genetic testing is included in the training recommendations for paediatric electrophysiology. National regulations for genetic testing and genetic counselling will need to be adhered to by the caregivers, and genetic counselling should be in cooperation with a specialised cardiac geneticist.

Requirements for general paediatric cardiology:

- Understand the conditions giving rise to cardiomyopathies and channelopathies;

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- Understand role of genetic testing in suspected inheritable arrhythmia syndromes;
- Knowledge of the principal genes involved in channelopathies.

Requirements for non-invasive and invasive electrophysiology training:
- Diagnosis and management (lifestyle and pharmacological) of the various inheritable arrhythmia syndromes;
- Risk stratification of sudden cardiac death and indications for implantable cardioverter defibrillator implantation in primary prevention as well as family counselling for sudden cardiac death;
- Understand the role of lifestyle changes, medications, and cardiac implantable electronic devices and sympathectomy or myectomy in these conditions.

For specific numbers regarding the practical skills at different levels, see Table 1.

Arrhythmias in adults with CHD

The diagnostics and therapy of adults with CHD is increasingly performed by specialized adult electrophysiologists with CHD teams in most parts of Europe. The population of adults with CHD is increasing and with age there is an increasing burden of arrhythmias which are often complex. The paediatric and congenital electrophysiology specialist should therefore be an indispensable member of the team for adults with CHD.

Requirements for general paediatric cardiology:
- Understand the effects of cardiac surgery in producing arrhythmia substrates;
- Understand the specific congenital defects associated with arrhythmias;
- Understand the risk of sudden death in different conditions;
- Be able to acutely diagnose and manage adults with CHD presenting with arrhythmias.

Requirements for non-invasive electrophysiology training:
- All items above, and;
- Manage acute and chronic arrhythmias;
- Role for devices and antiarrhythmic medication;
- Understand the role of acute and chronic anticoagulation and antiarrhythmic treatment;
- Indications for interventional management;
- Indications for surgical intervention for arrhythmia control;
- Manage arrhythmias during pregnancy in this population;
- Monitor and manage the risk of sudden death including sports participation and occupational choices.

Requirements for invasive electrophysiology training:
- All items in the two sections above, and;
- Plan and execute complex transcatheter ablation.

For specific numbers regarding the practical skills at different levels, see Table 1.

Written examination and certification process

Successful completion of the written exam is required for the non-invasive and invasive levels of the Association for European Paediatric and Congenital Cardiology electrophysiology training. As the number of annual trainees is considered to be low and developing an independent congenital written test is beyond the scope of the working group, cooperation with the European Heart Rhythm Association was established to meet standard criteria. In the written exam, a section with general electrophysiology questions will be provided by the European Heart Rhythm Association, and a second section with special paediatric and congenital electrophysiology questions will be prepared by selected members of the Association for European Paediatric and Congenital Cardiology Working Group for Cardiac Dysrhythmias and Electrophysiology. These members will be elected for a period of 3 years at the annual business meeting of the Working Group for Cardiac Dysrhythmias and Electrophysiology. The test will be offered at least biannually dependent on the number of applicants. Until 2022, the paediatric part of the IBHRE exam of the Heart Rhythm Society will be accepted as an alternative to the Association for European Paediatric and Congenital Cardiology/European Heart Rhythm Association paediatric and congenital electrophysiology examination.

For certification of the non-invasive and invasive levels of the logbook, a letter from the director(s) of the electrophysiology programme, a curriculum vitae, and a certification of the successful written examination should be sent to the council of the Association for European Paediatric and Congenital Cardiology Working Group for Cardiac Dysrhythmias and Electrophysiology. Official notification and presentation of the certificate will be performed at the working group annual business meeting.

Final comments

The Working Group for Cardiac Dysrhythmias and Electrophysiology of the Association for European Paediatric and Congenital Cardiology strongly recommends that ablation procedures and cardiac implantable electronic devices in children should be performed by or in cooperation with a paediatric electrophysiologist. Similarly in adults with CHD, ablation procedures and cardiac implantable electronic devices should be performed by or in cooperation with a paediatric and/or congenital electrophysiologist.

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