AMERICAN COLLEGE OF CARDIOLOGY FOUNDATION
AMERICAN HEART ASSOCIATION
AMERICAN ACADEMY OF PEDIATRICS

POLICY STATEMENT

Organizational Principles to Guide and Define the Child Health Care System and/or Improve the Health of All Children

ACCF/AHA/AAP RECOMMENDATIONS FOR TRAINING IN PEDIATRIC CARDIOLOGY

A Report of the American College of Cardiology Foundation/American Heart Association/American College of Physicians Task Force on Clinical Competence (ACC/AHA/AAP Writing Committee to Develop Training Recommendations for Pediatric Cardiology)

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Training Guidelines for Pediatric Cardiology Fellowship Programs

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INTRODUCTION

Pediatric cardiology is a complex, multifaceted specialty composed of diverse clinical and academic subspecialty areas. It is characterized by rapid growth of subspecialty areas and swift incorporation of new information from the clinical and laboratory sciences. It is important, therefore, to define the fellowship training required to launch a successful career in pediatric cardiology. The following document represents the first broad-based effort to do so.

In 2000, the Society of Pediatric Cardiology Training Program Directors (SPCTPD) embarked on the process of defining fellowship training guidelines. The process itself was broad-based and inclusive. All pediatric cardiology training program directors were invited to nominate members to participate in the training guidelines task forces; in turn, each task force was comprised of all nominated members who agreed to participate. Therefore, all training programs were provided an opportunity to actively participate.

In 2002, the American College of Cardiology (ACC) approved and published the Revised Recommendations in Adult Cardiovascular Medicine Core Cardiol-

ogy Training.[1] As the SPCTPD was concluding its training guideline development, plans were formalized to use a similar process through the ACC Pediatric Cardiology/Congenital Heart Disease Committee and the ACC Training Program Directors Committee. Accordingly, a steering committee was developed with original authors of the Pediatric Cardiology Training Guidelines to form a liaison with the ACC, the American Heart Association (AHA), and the Section on Pediatric Cardiology and Cardiac Surgery of the American Academy of Pediatrics (AAP) to agree on the final guidelines and to publish them widely.

These guidelines are written with the planned goal of serving as a practical resource for directors of pediatric cardiology training programs. We also hope that this document will prove useful to the Residency Review Committee (RRC) for pediatric training programs in the revision of requirements for the accreditation of pediatric cardiology programs. The general requirements, clinical competencies, and oversight for fellows in pediatric cardiology would remain the same as outlined by the Accreditation Council for Graduate Medical Education (ACGME).

GENERAL CONSIDERATIONS

The guidelines proposed in this document address overall recommendations for training in pediatric cardiology and important subspecialties within the field of pediatric cardiology. Although we understand that the pediatric RRC sets minimum standards for accreditation of fellowship programs, this document endeavors to define a more comprehensive set of guidelines for pediatric cardiology fellowship training. Fellowship training guidelines are presented for: general pediatric cardiology (including inpatient care and consultations); echocardiography and noninvasive imaging; electrophysiology; cardiac catheterization and intervention; cardiac intensive care; adult congenital heart disease; and research participation. Each section other than general pediatric cardiology specifies "core" and "advanced" training experiences. *Core* recommendations are intended to be common training experiences for all pediatric cardiology trainees regardless of long-term career goals. *Advanced* recommendations are additional training experiences for trainees intending to develop a clinical or academic area of special competence. All guidelines are recommended experiences, and not absolute mandates, as it is recognized that each training program has unique strengths and that clinical and academic variation across training programs provides important diversity for the specialty.

Table 1 summarizes the approximate time commitment (in months) recommended for core training in the task force reports that follow. Variations in these time commitments should be allowed, as pediatric cardiology programs vary widely in size, organization, and emphasis. For example, in some programs, fellows may get considerable cardiac intensive care unit training during their general inpatient experiences and not require a two- to four-month standalone rotation. Thus, the training guidelines must provide programs with flexibility to address individual trainee clinical and/or research training needs during a core fellowship of 36 months' duration.

TABLE 1. Core Training Recommendations

Experience	Time Commitment (in months)
General experience (inpatient)	3–6
Echocardiography/imaging	4–6
Cardiac catheterization	3–4 (estimate*)
Electrophysiology	2–3
Cardiac intensive care	2–4
Adult congenital heart disease	0–2 (estimate*)
Research	12–18
Total	36

* Task Force identified experience-based recommendations. See individual section for numbers.

The training program must possess the faculty expertise, patient volume, and inpatient/outpatient facilities to provide meaningful trainee experiences as outlined in this document. All faculty should be board certified or possess suitable equivalent qualifications. Recommendations for trainee and faculty evaluation are those outlined in the "general and special requirements" as published by the ACGME, and training should take place within a program that is accredited by the ACGME.

A comment about trainee research participation is appropriate. The field of pediatric cardiology is absolutely dependent upon research (basic and clinical) for meaningful progress. There is a critical need for the development of physician-scientists in our specialty to assure such future progress. Therefore, it is key that training programs begin to prepare trainees for a successful investigative career. Such preliminary research training will in most instances require 18 months or more. The balancing of clinical and research training will continue to be a major issue for training programs. It is highly probable that trainees who want to pursue a physician-scientist career will require at least four years of fellowship to begin the academic process and to finish training in the clinical areas. The authors are in complete agreement with the newly published American Board of Pediatrics (ABP) Training Requirements for subspecialty certification concerning scholarly activity, meaningful accomplishments in research, scholarship oversight, and differing pathways to train physician-scientists.

APPENDIX

The authors of this section declare they have no relationships with industry pertinent to this topic.

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Task Force 1: General Experiences and Training

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INTRODUCTION

The goals of pediatric cardiology training include acquiring the cognitive and procedural expertise required to provide high-quality care to children with cardiovascular disease, acquiring the academic skills to make meaningful scholarly contributions to the specialty, and, importantly, to develop the capacity for ongoing self-education beyond the years of formal training.

The general training of pediatric cardiology fellows builds on the general clinical and academic skills acquired during residency training. The pediatric cardiology fellow should be given broad exposure to clinical activities in pediatric cardiology inpatient and outpatient care, pediatric cardiology inpatient and outpatient consultations, and in preventive cardiology. The academic skills of formal presentation, small-group teaching, literature review, data analysis, and study design are also components of the general training guidelines.

CLINICAL TRAINING

A fundamental goal of clinical training is to acquire bedside diagnostic skill and the ability to provide high-qualilty consultative inpatient and outpatient pediatric cardiology care. The core skills of history-taking and physical examination are the only means for correctly initiating diagnostic and management options appropriate to the individual patient, and these must be heavily stressed at all points of patient contact. Pediatric cardiology fellows should be observed by faculty while performing key portions of the history and physical examination, and to also have the opportunity to observe faculty perform history-taking and physical examination, so that meaningful discussion of useful strategies and techniques may develop. Consultation services, general inpatient wards, and outpatient clinics all provide excellent opportunities for such interaction.

The pediatric cardiology fellow must have the opportunity to provide not only inpatient and outpatient consultation services but also direct patient care in both inpatient and outpatient settings. There must be a continuity of care in the outpatient clinic so that fellows can begin to appreciate the course of pediatric cardiac disease over time and its cumulative impact on individual patients and their families. The combined time commitment of the general inpatient and inpatient consultation services should be no less than three months. The continuity outpatient clinic should begin early in fellowship and continue throughout training, preferably on a biweekly basis. Both inpatient and outpatient experiences should include exposure to the management of the adult patient with congenital heart disease.

There are many ways for general inpatient and outpatient practices to be organized. In the delivery of high-level inpatient and outpatient care the pediatric cardiologist must demonstrate effective team leadership, accurate and efficient medical record keeping, sensitivity to medical ethical issues, an ability to communicate with and support patients and their families through stressful decisions and experiences, and show strict compliance with federal regulatory statutes. The general inpatient and outpatient training environment for pediatric cardiology fellows must provide full opportunity for observation, acquisition, and application of these skills by the trainee.

During the course of inpatient and outpatient activities the pediatric cardiology fellow will become familiar with a core knowledge base, as outlined in Table 1, at a minimum.

DIDACTIC CONTENT

The Core Curriculum

The program should offer courses, seminars, workshops, and/or laboratory experiences to provide appropriate background in basic and fundamental disciplines related to the heart and cardiovascular system. A lecture series encompassing a core curriculum in clinical and basic science topics must be provided for pediatric cardiology fellows. It should be designed so that the spectrum of topics presented will be completed at least once in the three years of accredited fellowship training. Pediatric cardiology fellows should contribute formal presentations of selected topics in the core curriculum, both to strengthen their knowledge base and to develop formal presentation skills. General areas to be covered in the core curriculum include those listed in Table 1.

TABLE 1. Core Knowledge Base

Anatomy and physiology of congenital heart defects (e.g., tetralogy of Fallot, hypoplastic left heart syndrome, ventricular septal defect)
Cardiac, autonomic and noncardiac causes of syncope and near-syncope
Cardiac MRI/CT
Cardiac sequelae of chronic hepatic disease
Cardiac sequelae of chronic renal disease
Cardiac sequelae of HIV/AIDS
Cardiac sequelae of obstructive sleep apnea
Cardiac sequelae of oncologic therapy
Cardiomyopathy, heart failure, and transplantation in the pediatric patient
Cardiopulmonary bypass
Cardiovascular pharmacology
Cardiovascular physiology and anatomy
Cardiovascular sequelae and follow-up in Marfan, William, DiGeorge, Turner, and Noonan syndromes
Cardiovascular sequelae of pregnancy and the impact of congenital heart disease
Cardiovascular sequelae of rheumatologic disease
Cardiovascular sports medicine
Care of the single ventricle patient
Cellular electrophysiology (e.g., action potentials and ion channels)
Chest pain
Clinical electrophysiology (e.g., mechanisms of arrhythmias, pacemakers, ablative therapy)
Coagulation and anticoagulation
Diagnosis and management of arrhythmias
Diagnosis and management of elevated pulmonary vascular resistance
Diagnosis and management of intravascular/intracardiac thrombosis
Diagnosis and management of left-to-right shunt lesions
Diagnosis and management of patent ductus arteriosus in premature infants
Diagnosis and management of right to left shunt lesions
Diagnosis and management of valvular heart disease, including artificial heart valves
Diagnostic evaluation of heart murmurs
Differential diagnosis and management of cardiac tumors
Differential diagnosis and management of pericardial effusion and pericardial tamponade
Embryonic, fetal, and postnatal cardiovascular development
Endocarditis
Exercise testing
Fetal/neonatal/perinatal cardiovascular physiology
Genetics of cardiovascular diseases of childhood
Hyperlipidemia
Hypertension
Kawasaki disease
Medical ethics
Normal cardiovascular anatomy and physiology, including exercise physiology
Obesity
Pericarditis and pericardial effusions
Physics of echocardiography and Doppler analysis
Physiology and natural history of congenital heart disease
Population health
Preventive cardiology, including prevention of adult acquired heart disease
Quality assurance and process improvement methodology
Rationale, expectations, and methods of screening for congenital heart disease in neonates with trisomy of chromosome 21, 18, or 13
Rationale, expectations, and methods of screening for congenital heart disease infants of diabetic pregnancies
Rationale, expectations, and methods of screening for congenital heart disease in the presence of neonatal emergencies such as gastroschisis, omphalocele, congenital diaphragmatic hernia, or cardiorespiratory failure leading to extracorporeal membrane oxygenation
Rheumatic fever
Risk factors in childhood and adolescence
Segmental cardiac analysis
Statistics and study design

Additional Conferences

Preoperative conferences with the cardiovascular surgical service are essential. Journal clubs are a recommended element of an academic environment and provide an excellent venue for participatory evaluation of study design and data analysis. Quality assurance evaluation and morbidity/mortality conferences should be held periodically. Multidisciplinary clinical and research conferences are highly desirable; according to the strengths of the institution, contributors might include neonatology, cardiothoracic surgery, adult cardiology, cardiac pathology, physiology, pharmacology, pulmonology, intensive care, cardiac anesthesiology, cardiovascular radiology, clinical genetics, molecular genetics, tissue engineering, stem cell biology, or developmental biology. In all of these conferences, pediatric cardiology fellows should be provided with active roles appropriate to their level of knowledge and training.

TEACHING AND EVALUATION SKILLS

It is a fundamental responsibility in academic medicine that those with the most experience must teach. The pediatric cardiology fellow will often be the most clinically experienced house officer on a team of residents, interns, and/or medical students. The fellow in that setting should be expected to provide lectures/seminars to the team of house officers. The pediatric cardiology fellow should also be allowed the opportunity to practice clinical leadership, organizational skills, and impromptu educational activities as appropriate to his/her demonstrated level of knowledge and training. There should be occasion for observation and critique of these skills by the attending physician as well as demonstration of these skills to the fellow by the attending.

Pediatric cardiology fellows should develop formal evaluation of trainees and training skills during their fellowship. To do so, they should participate in feedback to residents, students, and cardiology attendings throughout their rotations regarding their own educational and technical progress and the progress of other team members. Accurate self-evaluation is the most valuable skill of all and should be nurtured in all phases of pediatric cardiology training.

APPENDIX

The authors of this section declare they have no relationships with industry pertinent to this topic.

Task Force 2: Pediatric Training Guidelines for Noninvasive Cardiac Imaging

Endorsed by the American Society of Echocardiography and the Society of Pediatric Echocardiography

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INTRODUCTION

Noninvasive imaging, including echocardiography and magnetic resonance imaging (MRI), is a primary means for elucidating the anatomy and physiology of childhood heart disease. Competence in performance and interpretation of echocardiography and MRI is now essential to the practice of pediatric cardiology. Depending upon one's individual career goals, varying levels of expertise may be expected to be achieved during fellowship training. This document defines the levels of knowledge and expertise that pediatric cardiology trainees should acquire in echocardiography and MRI during training, and it offers guidelines for achieving these levels of competence.

Training guidelines have been previously published for pediatric echocardiography,[1] fetal echocardiography,[2] and pediatric transesophageal echocardiography.[3] Those documents were reviewed and considered during preparation of these guidelines. The guidelines presented here differ in some instances from previous recommendations because this task force recognizes that training programs have changed significantly over the decade since the last guidelines were promulgated.

PEDIATRIC ECHOCARDIOGRAPHY

Echocardiography, as used in this document, includes two-dimensional imaging of the heart and related structures, M-mode echocardiography for assessment of chamber size and function, color M-mode and Doppler tissue and flow mapping, pulsed and continuous-wave spectral Doppler flow analysis, and other variations of these basic modalities used to assess the structure and function of the heart and related organs, including new technologies such as three-dimensional echocardiography as they become available.

Facilities and Environment

The pediatric echocardiography laboratory should serve a hospital with inpatient and outpatient facilities, neonatal and pediatric intensive care units, a pediatric cardiac catheterization/interventional laboratory, and an active pediatric cardiac surgical program. The pediatric echocardiography laboratory should be under the supervision of a full-time pediatric cardiologist-echocardiographer qualified to direct a laboratory, and whose primary responsibility is supervision of the laboratory. The laboratory must perform a sufficient number of pediatric transthoracic, pediatric transesophageal, and fetal echocardiograms[1,4] each year to allow trainees sufficient exposure to both normal and abnormal examinations.

LEVELS OF EXPERTISE

Training goals defined here are to enable trainees to achieve one of two levels of expertise in echocardiography as appropriate for career goals.

Core

- Understanding of the general physical properties of ultrasound and clinical ultrasound technology.
- Ability to perform and interpret transthoracic echocardiography in normal infants, children and adolescents, and in those with childhood heart disease, with consultation as needed.
- Basic introduction to the principles of performing and interpreting transesophageal and fetal echocardiograms. Physicians with *core* expertise only are not expected to perform transesophageal and fetal echocardiograms independently.

Advanced

- Special expertise in performance and interpretation of transthoracic echocardiography in all forms of congenital and acquired pediatric heart disease, including the adult with congenital heart disease, enabling the practitioner to function independently.
- Ability to perform and interpret transesophageal and fetal echocardiography independently.
- Ability to supervise training and performance of sonographers, fellows, and other physicians.

TRAINING GUIDELINES

Core training should be achieved by all pediatric cardiology fellows during core clinical training, typically during four to six months dedicated to echocardiography over the course of the standard three-year training program. This level of expertise is anticipated to be sufficient for those fellows who do not plan to pursue echocardiography as an area of subspecialization.

Advanced training requires an additional 9 to 12 months of training and may be achieved through a dedicated experience in pediatric echocardiography after completion of core pediatric echocardiography instruction. This level of training is appropriate for those physicians who intend to be dedicated pediatric echocardiographers.

TRAINING GOALS

Successful completion of each training level should result in competence in the following specific areas.

Core

- Understanding of the physical properties of ultrasound.
- Proper, safe, and facile use of ultrasound instruments.
- Knowledge of the limitations of echocardiography.
- Recognition of cardiac structures displayed by echocardiography and the correlation between echocardiographic images and cardiac anatomy.
- Interpretation of Doppler flow information and deduction of cardiovascular physiology.
- Performance and interpretation of complete transthoracic two-dimensional and M-mode echocardiograms, Doppler color-flow mapping, and pulsed- and continuous-wave spectral Doppler flow analysis in normal pediatric patients and in those with childhood heart disease, with consultation as needed.
- Assessment of systolic, diastolic, and regional myocardial function in normal pediatric patients and those with childhood heart disease, with consultation as needed.
- Ability to review critically published clinical research in echocardiography.

Advanced

In addition to *core* competencies, other goals include:

- Independent performance and interpretation of complete transthoracic two-dimensional and M-mode echocardiograms, Doppler color-flow mapping, and pulsed- and continuous-wave spectral Doppler flow analysis in normal pediatric patients and in those with childhood heart disease.
- Independent assessment of systolic, diastolic and regional myocardial function in normal pediatric patients and in those with congenital or acquired heart disease, to include stress echocardiographic studies.
- Special expertise in the performance and interpretation of pediatric transthoracic, pediatric transesophageal, and fetal echocardiography.
- Training of sonographers and junior pediatric cardiology trainees.
- Participation in basic or clinical research in echocardiography, including presenting original data at one or more scientific meetings.

TRAINING METHODS

Each level of training may be achieved by the methods outlined in the following text or by comparable alternative methods. A summary of the recommended minimum number of procedures is found in Table 1.

TABLE 1. Echocardiography Training—Recommended Minimum Procedure Numbers

Core training	
TTE perform and interpret (≤1 year of age)	150 (50)
TTE review	150
Advanced training*	
TTE perform and interpret (≤1 year of age)	200 (50)
TTE review	200
TEE perform and interpret	50
Fetal echocardiogram	50

* Numbers are in addition to those obtained during core training.
TEE = transesophageal echocardiogram; TTE = transthoracic echocardiogram.

Core

Each trainee should perform and interpret at least 150 pediatric echocardiograms, including at least 50 in patients one year of age or younger, under the supervision of the laboratory director or other qualified staff pediatric cardiologist-echocardiographer(s). Each trainee should also review at least 150 additional pediatric echocardiograms.

In addition, the laboratory director or other staff pediatric cardiologist-echocardiographer(s) should conduct regular laboratory conferences with the trainee(s) to present illustrative cases and to teach proper interpretation and the limitations of echocardiography. Pathological specimens, models, or photographs for echocardiographic-anatomic correlation are excellent teaching aids that should be incorporated wherever possible.

Integration of echocardiography into the clinical practice of pediatric cardiology should be demonstrated on inpatient and outpatient rotations and at medical-surgical management conferences.

Research training for pediatric cardiology trainees should include active participation in reviews of scientific journal articles that pertain to echocardiography.

Advanced

Each *advanced*-level trainee should perform and interpret at least 200 additional pediatric transthoracic echocardiograms and review, or perform and interpret, another 200 pediatric echocardiograms. As with core training, at least 50 of these should be done in infants one year of age or younger. Each trainee should perform a significant number of echocardiograms independently (one-third to one-half of the exams), with subsequent review and critique of the examination by the responsible staff pediatric cardiologist-echocardiographer. Teaching methods outlined in the previous text should be continued here.

Each *advanced*-level trainee should perform and interpret at least 50 pediatric transesophageal echocardiograms, including manipulation of the transducer and registration of images, under direct supervision by a dedicated pediatric cardiologist-echocardiographer. The trainee should perform intubation of the esophagus in at least 20 patients under the direct supervision of a pediatric cardiologist-echocardiographer or anesthesiologist experienced in the procedure. An ideal environment for learning pediatric transesophageal echocardiography is the operating suite during performance of intraoperative

examinations, but the training experience should not be limited to this venue and should include the intensive care unit, cardiac catheterization suite, and outpatient examinations.

Each *advanced* trainee should perform and/or review at least 50 fetal echocardiograms. The trainee must master the fundamental skills of determining fetal position, situs, cardiac anatomy, and cardiac rhythm under the supervision of a dedicated pediatric cardiologist-echocardiographer. The trainee should observe and participate in the discussion of the findings with the parents by the staff echocardiographer responsible for the examination. As the trainee's experience progresses, a significant proportion (30% to 50%) of studies should be performed independently, including cases with normal and abnormal cardiac anatomy and rhythm, with supervision by a dedicated pediatric cardiologist-echocardiographer. Each trainee should understand how to recognize and approach fetal heart failure, and he or she should understand the association of fetal heart disease with extracardiac structural abnormalities, syndromes, and chromosomal abnormalities.

Research training for pediatric cardiology trainees should include, at a minimum, active participation in reviews of scientific journal articles that pertain to echocardiography. In addition, participation in basic or clinical research in echocardiography should be encouraged.

Each *advanced*-level trainee should be given responsibility for participating in the training of sonographers and junior pediatric cardiology fellows, initially with supervision of the laboratory director and then independently and also presenting echocardiography-related teaching conferences and formal didactic lectures.

EVALUATION

The laboratory director, in consultation with the teaching staff, should evaluate each trainee in writing on a regular basis. Trainees should maintain a log of all echocardiograms performed and reviewed, including the age of the patient and the diagnosis. The log should be reviewed regularly by both the laboratory director and the training program director to ensure that each trainee is obtaining adequate and balanced experience.

The evaluation should be reviewed with each trainee and a written copy provided. If a trainee does not appear to be progressing adequately during the rotation, a meeting should be scheduled as soon as possible to inform the trainee and to discuss potential remedial measures. The evaluation should be based on achievement of the expected levels of competence in the areas outlined in the previous text.

Direct observation of the trainee during performance of echocardiograms provides information about imaging skills and understanding of the ultrasound instruments. Conferences in which echocardiograms are presented provide an opportunity to assess skills in interpretation of images and Doppler recordings. The trainees' understanding of research design and methods and ability to review research can be critically evaluated during journal club meetings or other venues for medical literature review. Teaching skills and effectiveness can be evaluated by direct observation and from evaluations by sonographers and more junior trainees and by performance at teaching conferences prepared and delivered by trainees.

Pediatric Cardiovascular Magnetic Resonance Imaging

Magnetic resonance imaging (MRI) as used in this document includes anatomic and functional cardiovascular MRI in congenital and acquired pediatric heart disease as well as in the adult with congenital heart disease. At present, there are no specific guidelines for training or credentialing in pediatric cardiovascular MRI. It is likely that the training guidelines for pediatric cardiovascular MRI proposed here will require amendment as the field evolves. These guidelines must be considered as goals and should not be considered as requirements.

LEVELS OF EXPERTISE

Trainees may achieve one of two levels of expertise in pediatric cardiovascular MRI as appropriate for career goals.

Core

- Familiarity with the general physical principles upon which MRI is based.
- Ability to view and understand MR images in normal infants, children, and adolescents and those with childhood heart disease.
- Introduction to commonly used imaging protocols and MRI terminology.

Advanced

- Thorough understanding of clinical MRI instruments and the imaging protocols used for cardiovascular imaging and physiological analysis (e.g., quantitative analysis of ventricular function and blood flow).
- Ability to independently perform and interpret all types of MRI in childhood heart disease and congenital heart disease at all ages.
- Ability to supervise training of technologists, fellows, and other physicians.

TRAINING GUIDELINES

Training in pediatric cardiovascular MRI should occur within a pediatric cardiology fellowship program and/or a pediatric radiology training program accredited by the Accreditation Council for Graduate Medical Education (ACGME). The MR laboratory should serve a hospital with both inpatient and outpatient facilities, neonatal and pediatric intensive care units, a pediatric cardiac catheterization/interventional laboratory, and an active pediatric cardiac surgical program. The MRI laboratory should be under the supervision of a full-time cardiologist and/or radiologist qualified in cardiovascular MRI, and it must perform a sufficient number of annual examinations to allow each trainee sufficient exposure to both normal and abnormal examinations.

Core training should be achieved by all pediatric cardiology fellows during the core clinical years of the program. This level of expertise may be sufficient for those fellows who plan to practice clinical pediatric cardiology with access to a pediatric cardiologist or radiologist with special expertise in pediatric cardiovascular MRI.

Advanced training requires a minimum of six months of instruction in addition to *core* training. This level of training is appropriate for those physicians who intend to have special expertise in pediatric cardiovascular MRI and is recommended for directors of pediatric cardiovascular MRI laboratories.

TRAINING GOALS

Successful completion of each training level should result in competence in the following specific areas.

Core

- Physical principles of MRI and physiologic analysis.
- Limitations of, and contraindications to, MRI.
- Recognition of cardiac structures displayed by MRI and the correlation between MR images and cardiac anatomy.
- Basic familiarity with commonly used imaging protocols, their clinical uses, and MRI terminology.
- Critical review of published clinical research in pediatric cardiovascular MRI.

Advanced

- Thorough understanding of MRI physics, instrumentation, nomenclature, and safety.
- Special expertise in the performance and interpretation of pediatric cardiovascular MRI, including all commonly used imaging and flow analysis protocols.
- Training of technologists and junior pediatric cardiology trainees.
- Management of and quality assurance for the MRI laboratory.
- Basic or clinical research in pediatric cardiovascular MRI, including presenting original data at one or more scientific meetings.

TRAINING METHODS

Each level of training may be achieved by the methods outlined in the following text or by comparable alternative methods.

Core

Pediatric cardiology trainees should gain exposure to cardiovascular MRI through active review of scientific journal articles that pertain to pediatric cardiovascular MRI, discussion with cardiologists and radiologists who perform cardiovascular MRI, and, if possible, review of cardiovascular MRI examinations.

Advanced

During a fellowship in pediatric cardiovascular MRI, each trainee should perform and/or interpret at least 100 cardiovascular MRI examinations in patients with congenital or acquired childhood heart disease, including adult patients with congenital heart disease. As the trainee's experience progresses, an increasing proportion of these examinations should be performed independently, with review and critique by the laboratory director.

Research training should include continued critical review of the pediatric cardiovascular MRI literature and an opportunity to perform basic or clinical research leading to publication or presentation of scientific data.

Each trainee should be given responsibility for participating in the training of technologists and junior pediatric cardiology fellows, initially with supervision of the laboratory director and subsequently independently. In addition, each trainee should have opportunities to observe and participate in the management of the laboratory, especially quality improvement initiatives.

EVALUATION

The laboratory director, in consultation with the teaching staff, should evaluate each trainee in writing. The evaluation should be reviewed with each trainee and a written copy provided. The trainee should maintain a log of all examinations performed and reviewed, including the age of the patient, diagnosis, and role of the trainee in the examination.

APPENDIX

The authors of this section declare they have no relationships with industry pertinent to this topic.

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Task Force 3: Training Guidelines for Pediatric Cardiac Catheterization and Interventional Cardiology

Endorsed by the Society for Cardiovascular Angiography and Interventions

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INTRODUCTION

The purpose of this document is to recommend minimum training experiences in cardiac catheterization for clinical fellows in pediatric cardiology training programs. Training guidelines in cardiac catheterization are well-established in adult cardiovascular medicine,[1,2] and they have been considered recently in pediatric cardiology as well.[3,4]

Pediatric cardiac catheterization is a unique specialty encompassing a wide range of diagnostic and therapeutic techniques applied to a diverse group of congenital and acquired cardiovascular disorders. A physician who performs a pediatric cardiac catheterization must possess the technical skills and clinical judgment to safely and accurately perform a thorough diagnostic cardiac catheterization and angiographic study. Furthermore, an interventional pediatric cardiologist must also assess the indications for a catheter intervention, including the risks of performing or not performing the procedure (i.e., requires knowledge of the natural history of the defect), and must skillfully perform the appropriate catheter intervention. It is appropriate, therefore, to delineate minimal training requirements in cardiac catheterization for pediatric cardiology trainees.

There are no studies relating training experiences to subsequent clinical skill in pediatric cardiac catheterization. Therefore, the recommendations in Task Force 3 represent the opinions of the authors. To help guide this process, all Accreditation Council for Graduate Medical Education (ACGME)-accredited pediatric cardiology training programs were surveyed in 2001 to inquire about current practices and opinions regarding fellow training in pediatric cardiac catheterization and intervention. Thirty-two programs responded. The responses represented the opinions of fellowship directors (n = 21), catheterization laboratory directors (n = 15), and division directors (n = 13) (in some programs one individual holds more than one position). This document draws on this Training Program Survey to help define training guidelines in this specialty.

FACILITIES AND ENVIRONMENT

Training in cardiac catheterization should occur within a pediatric cardiology fellowship program that is accredited by the ACGME. The cardiac catheterization laboratory should serve a hospital with inpatient and outpatient facilities, neonatal and pediatric intensive care units, and an active pediatric cardiac surgical program. The pediatric cardiac catheterization laboratory should be under the supervision of a full-time pediatric cardiologist, whose primary responsibility is supervision of the laboratory. The laboratory must perform a sufficient number of cardiac catheterizations and interventional procedures to provide each trainee with an acceptable experience.

The cardiac catheterization program must have a regular teaching conference in which diagnostic data (hemodynamic and angiographic) and therapeutic outcomes are formally discussed. In addition, each program that provides *advanced* interventional training must have a regular morbidity and mortality conference in which all adverse outcomes of catheter interventions are systematically reviewed. Participants in this conference should include cardiology faculty, clinical fellows, and preferably pediatric cardiothoracic surgeons and cardiac anesthesiologists. Active participation in these conferences by all clinical cardiology fellows, particularly those at *advanced* levels, is essential to clinical training that emphasizes quality outcomes.

LEVELS OF EXPERTISE

In this report we discuss *core* training for all fellows, and *advanced* training for fellows desiring special expertise in cardiac catheterization and interventional cardiology. The *core* training is recommended for all clinical fellows during their core clinical experience. It is intended to be sufficient for fellows who do not plan a career in interventional pediatric cardiology, but who may be required to perform simple diagnostic studies and to interpret catheterization and angiographic data in their clinical practices. (Cardiologists who provide "diagnostic only" catheterization services must coordinate the care closely with interventional cardiologists and surgeons at referral centers to minimize the need for repeat catheterization procedures.) The *advanced* training provides expertise in both diagnostic and interventional catheterization procedures, and it is intended to qualify a fellow to embark upon a career in cardiac catheterization and intervention.

Core Training: Goals and Methods

Core training in cardiac catheterization refers to the training experiences recommended for all clinical cardiology fellows, regardless of specific career goals. In the Training Program Survey, there was unanimous support for core training in cardiac catheterization for all clinical fellows. The goal of such

TABLE 1. Recommended Body of Knowledge Covered During Core Training

- Indications for and risks of cardiac catheterization and angiography
- Indications for and risks of therapeutic catheter procedures
- Interpretation of pressure waveforms
- Interpretation of O_2 saturation data
- Fick principle and shunt calculations
- Vascular resistance calculations
- Cardiac angiography: basic techniques/angles/interpretation
- Radiation safety

core training is to introduce fellows to the field of cardiac catheterization and the risks and benefits of catheter-based procedures, to teach basic diagnostic catheterization skills, and to provide a basic knowledge of hemodynamics, angiography, and radiation safety. A core curriculum in pediatric cardiac catheterization should include the topics and experiences outlined in Table 1.

The core training should involve each clinical fellow in a minimum of 100 cardiac catheterizations, at least 20 of which include an interventional component (Table 2). These experiences should familiarize the fellow to the indications for cardiac catheterization and intervention, femoral vessel access techniques, basic catheter manipulations, hemodynamic measurements and calculations, and angiographic interpretations. Participation by the fellow as either the primary operator or the primary assistant is satisfactory involvement. A log book should be maintained by the fellow to document the experience and outcomes of catheterization.

Advanced Training: Goals and Methods

Advanced training in cardiac catheterization refers to the training recommended for pediatric cardiology fellows who intend to pursue a career in pediatric cardiac catheterization and interventional cardiology. Therefore, the advanced training goal is to prepare the trainee to independently perform diagnostic and therapeutic catheter procedures with excellent outcomes. Prerequisite to these advanced training experiences is the successful completion of core training. Advanced training should involve each fellow in a minimum of 200 catheterization procedures, at least 100 of which are interventional. The minimum recommended numbers of procedures are specified in Table 3 (and are in addition to those obtained during the core training). The procedure types and numbers in Table 3 are recommended guidelines, not mandates, as it is understood that some qualified programs may not perform every procedure. Participation by the fellow as either the primary operator or the primary assistant is satisfactory involvement.

TABLE 2. Core Training—Recommended Minimum Case Numbers*

Total cardiac catheterizations	100
Interventional procedures	20
Type of intervention	
Balloon septostomy†	5
Other	Not specified

* Numbers represent the median response from the Training Program Survey.
† Fluoroscopic orechocardiographic guidance.

TABLE 3. Advanced Training—Recommended Minimum Case Numbers*

Total cardiac catheterizations	200
Interventional procedures	100
Type of intervention	
Balloon septostomy†	5
Transseptal puncture	10
Pulmonary valve dilation	10 (5 newborns)
Aortic valve dilation	10 (5 newborns)
Pulmonary artery dilation	10
Pulmonary artery stent	10
Coarctation dilation	10
Coarctation stent	5
Collateral occlusion	10
Ductus arteriosus occlusion	10
Atrial septal defect occlusion	10

* Numbers represent the median response from the Training Program Survey.
† Fluoroscopic or echocardiographic guidance.

A minimum number of procedures is necessary, but this is not sufficient to prepare a trainee for a career in cardiac catheterization and intervention. Also important to a successful career, and perhaps more crucial, are technical facility and good clinical judgment. During advanced training the trainee must acquire sophisticated skills in complex catheter manipulations, wire and sheath exchanges, device implantation techniques, and retrievals. Furthermore, good clinical judgment regarding the indications for and against intervention require a thorough knowledge of the natural history of congenital cardiac defects,[5,6] and of the medical, catheter, and surgical options available for treatment. It is the responsibility of the training program director to assure that each advanced trainee graduates with the technical skills, clinical judgment, and cognitive knowledge to pursue an independent career in pediatric cardiac catheterization.

A log book is to be maintained by the advanced fellow to document the nature and outcome of each diagnostic and interventional procedure he or she participated in throughout training. The fellow should also participate actively in regular cardiac catheterization teaching and morbidity conferences where outcomes and complications of interventional procedures are thoroughly discussed (see the previous text). Finally, it is strongly recommended that the advanced fellow participate in at least one clinical research project related to cardiac catheterization and/or interventional cardiology.

Advanced training in pediatric cardiac catheterization requires a dedicated 12-month experience, at a minimum. Some fellowship programs may be able to offer the recommended advanced training experiences during a 3- or 3.5-year training program. Nevertheless, even in those programs additional training provides the fellow an opportunity to enhance technical skills and clinical judgment in this very complex specialty. The authors of this document believe that the highest-quality training is obtained during a fourth-year experience. Three or 3.5 years of training may be satisfactory for some individuals if all advanced training guidelines are achieved, and partic-

APPENDIX. Author Relationships With Industry and Others

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ularly if the fellow's next postgraduate position can be anticipated to provide ongoing mentoring for complex interventions.

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Task Force 4: Recommendations for Training Guidelines in Pediatric Cardiac Electrophysiology

Endorsed by the Heart Rhythm Society

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INTRODUCTION

The field of clinical cardiac electrophysiology has rapidly expanded over the past 30 years. Advances in the diagnosis and treatment of pediatric cardiac rhythm disorders, and the increasing trend in medicine in general to develop criteria or guidelines for competence and training in specific fields, have led to the need to develop guidelines for training in pediatric clinical cardiac electrophysiology (CCEP).

The American College of Cardiology (ACC), American Heart Association (AHA), and Heart Rhythm Society (formerly NASPE) have addressed training guidelines in adult CCEP.[1–3] The extensive body of literature regarding adult CCEP training and basic electrophysiology (EP) knowledge provides an important background and should be applied in an appropriately modified form to pediatric CCEP training.[4–21] Recognizing the considerable differences in the pediatric and adult cardiology populations, guidelines that are unique to the pediatric and congenital heart disease population must be developed. Canadian recommendations for training in pediatric EP have been published.[22] It should be recognized that pediatric patients are unique, as recognized by the separate training programs and board certification for pediatricians and internists, and for adult and pediatric cardiologists. In addition, the pediatric electrophysiologist will have experience and expertise in groups unique to pediatric cardiac electrophysiology, including the fetus with in utero arrhythmias, the child with a structurally normal heart and supraventricular tachycardia, ventricular tachycardia, or other arrhythmias, the child with preoperative or postoperative arrhythmias after surgery for congenital heart disease, and the adult with congenital heart disease, both in the pre- and postoperative states. This unique group of adults with congenital heart disease is best served by those with a combined knowledge of congenital heart disease and age-specific disease processes, whether this be provided by a combination of pediatric and adult cardiologists or single individuals with broad training or dual training in pediatric and adult cardiology.

FACILITIES AND ENVIRONMENT

Training should be obtained in an Accreditation Council for Graduate Medical Education (ACGME)-accredited pediatric cardiology training program. Recommendations for catheter ablation facilities have been published.[2,9] Pediatric catheterization laboratory facilities should be available with the appropriate EP equipment to perform EP studies and catheter ablation. These facilities should ensure a safe, sterile, and effective environment for invasive EP studies and implantation of pacemakers and arrhythmia control devices. In many settings, the operating room can be used for the pacing/arrhythmia control devices. Although experience at outside institutions, including adult programs, may be valuable, no more than two to four months of the one-year advanced training should be spent at other institutions. In particular, added experience in pacemaker and implantable cardioverter-defibrillator (ICD) implantation, as well as in ventricular tachycardia studies, may be acquired at a certified adult CCEP program, provided that it is within the previously noted time frame.

At least one board-certified pediatric cardiologist with advanced CCEP skills should be identified as the director of the core and advanced Electrophysiology Training Program. Because there is currently no pediatric EP examination, consideration should be given for one pediatric EP faculty member to take the NASPExAM, or its successor examination. For advanced training of fellows, at least one faculty member should be skilled in the implantation of pacemakers and ICDs.

LEVELS OF EXPERTISE

In this report we discuss *core* training for all fellows and *advanced* training for fellows desiring special expertise in pediatric CCEP. The *core* training is recommended for all clinical fellows during their core clinical experience. It is intended to be sufficient for fellows who do not plan a career in EP. The *advanced* training provides expertise in both diagnostic and therapeutic EP and it is intended to qualify a fellow to embark upon a career in pediatric CCEP. Within the *advanced* level are two tracks related to expertise in pacemaker/ICD care: track 1 physicians prescribe and follow patients who require pacemaker/ICD care; track 2 physicians will also be skilled in device implantation.

Core Training: Goals and Methods

Core EP training is required of all trainees to be a competent pediatric cardiologist. The goal is to enable all trainees to be skilled in electrocardiographic (ECG) interpretation, including standard, ambulatory (Holter), exercise ECGs, and transtelephonic ECGs.

Additionally, the trainee should understand the indications for and the use of noninvasive diagnostic techniques including exercise testing, 24-h ambulatory and event monitors, and tilt table testing and should have a general understanding of their interpretation. All trainees should be able to properly interpret cardiac arrhythmias and manage arrhythmias in the acute care setting. There should be an understanding of the use of non-pharmacologic methods and pharmacologic agents to treat arrhythmias, including drug interactions and proarrhythmic potential. The trainee should understand the indications for the selection of patients for specialized electrophysiologic studies, including ablation. In addition, the trainee should obtain a basic understanding of the indications for, and the information obtained from, invasive EP studies. This should include an understanding of the use of information obtained from these testing modalities for the management of the patient's clinical condition. The trainee should have skills in the interpretation of basic EP information obtained from electrophysiology study (EPS).

Participation in at least 10 EPS cases including catheter placement and analysis of electrophysiologic tracings are needed to acquire these skills. The trainee should understand the evaluation of patients with syncope, palpitations, chest pain, and irregular heart rhythms. All trainees should understand the indications for pacemaker placement, know the differences in pacing modes, understand and be able to perform basic pacemaker interrogation, reprogram and troubleshoot pacemakers, recognizing basic malfunctions such as capture failure, sensing malfunctions, and battery end of service characteristics. Participation by the trainee in at least 20 pacemaker evaluations is recommended to develop these skills. The trainee should receive instruction in the insertion, management, and follow-up of temporary pacemakers, including measurement of pacing and sensing thresholds. He or she should understand the general indications for consideration of the use of arrhythmia control devices (ICDs and anti-tachycardia devices) and know when to refer these patients for more advanced EP evaluation. The trainee should understand the indications and techniques for elective and emergency cardioversion. Four elective direct current cardioversions are required.

The core training to obtain the previously described skills and knowledge should occur in the first three years of pediatric cardiology training and be equivalent to two to three months of concentrated study, but may be acquired throughout the three years as needed to obtain designated competence skills (Table 1).

Advanced Training (Year 4 ± Year 5): Goals and Methods

The goal of *advanced* training is to enable the pediatric electrophysiologist to perform, interpret, and train others to conduct and interpret specific procedures at a high skill level. Tables 2 and 3 describe the competence skills necessary for advanced-level training. The recommended minimum procedures are summarized in Table 4 for both core and advanced training.

Advanced-level skills involve understanding the evaluation and management of common arrhythmias, from the fetus to young adult. In addition, advanced understanding of complex arrhythmia management, especially in the postoperative period after repair of congenital heart defects and in special

TABLE 1. Core Competence Skills

- Interpretation of ECGs, Holters, exercise testing, and event monitors with arrhythmia recognition
- Recognition of developmental changes in cardiac rates and rhythm with age and of "normal" variants of rhythm
- Management of arrhythmias in the acute care setting, including uses of pharmacologic agents, cardioversion with esophageal or intracardiac pacing, and direct current cardioversion
- Management of common chronic arrhythmias such as infant supraventricular tachycardia
- Evaluation of the patient with documented arrhythmia, symptoms of arrhythmia (palpitations, increased or decreased heart rate, irregular heart rhythm), and syncope or presyncope
- Treatment of patients with all forms of syncope
- Evaluation of patients with long QT syndrome or family history of sudden death and management of these patients
- Knowledge of indications for use of noninvasive EP testing
- Knowledge of indications for invasive EP studies and general understanding of information obtained from EPS, including interpretation of basic EP information
- Knowledge of indications for catheter ablation, understanding of procedure and complications of procedure
- Knowledge of indications for pacing, anti-tachycardia device, and ICD placement
- Knowledge of pacing modes, basic pacemaker interrogation, reprogramming, and trouble-shooting for loss of capture, under or over sensing, battery end of life
- Temporary transvenous and transcutaneouspacing
- Evaluation of EP literature

TABLE 2. Advanced EP Clinical Competence Skills

Advanced competence skills include core basic skills plus:

- Management of all types of cardiac arrhythmias in all ages from the fetus to young adult
- Evaluation and management of patients with specific arrhythmia syndromes including long QT syndrome, Brugada syndrome, and right ventricular dysplasia
- Evaluation of patients with family history of sudden cardiac death
- Management of complex arrhythmias, especially in postoperative congenital heart disease patients
- Evaluation of patient with syncope including, when appropriate, performance of tilt table testing with appropriate interpretation and management of patient
- Performance of esophageal EPS
- Knowledge of the indications, risks, and benefits of EPS/catheter ablation
- Interpretation and use of EPS data
- Technical and cognitive skills to perform EPS/catheter ablation, using current mapping technology and techniques
- Advanced knowledge of selection of pacemaker type, programming, follow-up, and trouble-shooting
- Advanced knowledge of pacemakers and implantable cardioverter-defibrillators
- Intraoperative evaluation and programming of pacemakers and ICDs

TABLE 3. Advanced EP Research Competence Skills

- Evaluation of EP literature
- Development of clinical research skills
- Completions of EP project which results in an abstract and/or manuscript
- Grant submission is encouraged

groups such as long QT syndrome, Brugada syndrome, and right ventricular dysplasia, should be attained. Evaluation and management of the patient with all forms of syncope should be accomplished, including the performance of tilt table testing when appropriate. In those programs that employ tilt testing, participation in at least 10 procedures in a pediatric or adult laboratory is advisable. A thorough understanding of pathophysiology and therapy of syncope and tilt testing should be required of all trainees. Advanced-level trainees should develop the cognitive skills to evaluate the patient with a family history of sudden cardiac arrest or death. Skill and experience should be encouraged in pediatric EPS interpretation and use of the EP data to make management and therapeutic decisions. Experience with esophageal EPS should be obtained with participation in 10 procedures. The indications, risks, and benefits of these procedures should be known.

Advanced-level trainees will develop technical and cognitive skills and experience in the performance of invasive diagnostic and therapeutic CCEP. At least 75 diagnostic intracardiac EPS should be performed, of which at least 10 should be patients with ventricular tachycardia. At least 40 of these diagnostic procedures must be in patients who are 12 years of age or younger, and at least 10 should be in patients with repaired or palliated congenital heart disease. In addition, participation in at least 40 catheter ablation procedures is required. The diagnostic portion of a catheter ablation procedure may be used to satisfy the requirement for participation in 75 diagnostic procedures. Participation should include scrubbing for the case, catheter manipulation, analysis, review of tracings, and generation of a report.

Advanced understanding of pacemaker indications, optimal pacemaker choices, and follow-up of pacemaker patients should be obtained. The Heart Rhythm Society has recommended two tracks for those caring for pacemaker patients. Track 1 involves electrophysiologists who will be involved in prescribing and following pacemaker and ICD patients. Track 2 individuals prescribe, implant, and follow patients with pacemakers and ICDs. In both tracks, advanced understanding of pacemaker and ICD indications, optimal pacemaker choices, and evaluation or follow-up of 75 pacemaker/ICD patients should be obtained. In addition, attendance—including intraoperative testing of 35 pacemaker or ICD implants (20 new, 10 revisions, 5 ICDs)—is required. To implant pacemakers and ICDs, direct participation in a total of at least 50 pacemaker and device implants is required, of which a reasonable number should be complex devices including ICDs. As new technology develops, the number of device implants necessary to achieve competence may change. Participation should include scrubbing for the surgery, catheter manipulation, participation in intraoperative testing, and generation of a report. As the skills for implanting devices in smaller children are specific to pediatric EP, at least 15 of these implantation procedures should be in children less than 12 years of age. Also, experience with implantation in patients with repaired congenital heart disease is essential.

Advanced-level pediatric electrophysiologists should have all the skills noted in the previous text, but they may or may not perform the implantation of pacemakers and ICDs. If the pediatric clinical cardiac electrophysiologist does not actually perform these

TABLE 4. Core and Advanced Training: Recommended Minimum Experiences

Level of Training	Core Pediatric Cardiology Training	Advanced Pediatric EP Training
Training time	2 to 3 months equivalent	12 months or more post general PC training*
ECG interpretation	500†	1,500
Ambulatory ECG interpretation	50	200
Exercise ECG	10	40
Tilt table tests	2	10
Transesophageal EPS/temporary postoperative epicardial wire study	5	10
Intracardiac EPS	10	75‡
Intracardiac EPS 12 years of age or less		40
Intracardiac EPS in repaired congenital heart disease		10
Catheter ablation	5	40
Catheter ablation 12 years of age of age or less		20
Catheter ablation in repaired congential heart disease		10
DC cardioversion	4	10
Pacemaker + ICD		
Evaluations/follow-up	20	50
Intraoperative evaluation pacemakers and devices		35 (20 new, 10 revisions, 5 ICDs)
Track 2: implant pacemaker and complex devices		50 (15 in ages 12 yrs or less)

* 4 to 6 months of this training could be obtained during a regular 3-year pediatric cardiology training program if it did not interfere with other required training.
† ECG reading may be performed throughout three-year fellowship.
‡ The diagnostic portion of an ablation procedure may be used to satisfy this requirement.

procedures, they should participate in the intraoperative evaluation and postoperative care. Advanced-level training is expected for any pediatric electrophysiologist who implants pacemakers and ICDs. An additional one to two years after the general cardiology training program is required to achieve advanced-level training. Supplementary training may be required to achieve track 2 implantation competence. Part of this experience with implantation may be gained in an outside program or an affiliated adult CCEP training program. Until specific pediatric pacemaker and ICD certification is available, consideration should be given for advanced trainees implanting pacemakers and ICDs to take the NASPE examination.

Specific Program Content (Core and Advanced Levels)

Trainees will be expected to develop an appropriate level of knowledge and experience in the following areas:

- Basic cellular and whole organ EP related to normal physiology and cardiac arrhythmias in all pediatric and adult congenital patients.
- Pharmacologic principles underlying the use of antiarrhythmic drugs and the effects of various conditions encountered in pediatrics on the use of those drugs (prematurity, developmental biologic changes, including those in volume of distribution, hepatic and renal clearance, drug interactions, and congestive heart failure).
- Management of pediatric and adult patients with congenital heart disease and cardiac arrhythmias; knowledge of presentation and natural history of the variety of arrhythmias encountered in pediatric electrophysiology practice; understanding of the effects of various management strategies on the physiology and psychology of the pediatric and congenital heart patient.
- Expertise in the use of the ECG and other noninvasive specialized testing, including ambulatory monitoring, transtelephonic monitoring, exercise stress testing, and tilt table testing to evaluate cardiac arrhythmias and symptoms.
- An understanding of the indications, contraindications, and potential risks and benefits of intracardiac EPS and esophageal EPS. Core-level trainees should have a general understanding of the information provided by EPS and recognize basic information provided such as site of heart block, identification of mechanism of the arrhythmia, and location of accessory pathways or focal arrhythmia sites. Advanced-level trainees should have experience with esophageal EPS for the treatment and evaluation of arrhythmias. Advanced trainees should also develop an advanced understanding of intracardiac EPS interpretation and use of the data for management. In addition, advanced trainees should develop the advanced cognitive and technical skills to perform EPS.
- Proficiency in the use of esophageal, temporary postoperative epicardial wire, and intracardiac EPS for diagnosis and treatment should be achieved. This includes the ability to manipulate catheters, knowledge of EP equipment and catheters, and ability to perform the full spectrum of programmed electrical stimulation and intracardiac mapping and to interpret the results.
- Advanced trainees should develop the full spectrum of cognitive and technical skills in all types of catheter ablation in children and young adults with congenital heart disease. Advanced trainees should develop skills in the indications for and

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Dr. George F. Van Hare	None	• Medtronic	None	None	None	None	• Support for fellow training—Medtronic
Dr. Edward P. Walsh	None	None	None	None	None	None	

potential complications of catheter ablation and should be prepared to treat any of these complications. During the four years of training, the advanced trainee should develop skills in transseptal perforation by participating in at least 10 transseptal procedures. Trainees should have exposure to and develop skills in manipulation of ablation catheters for antegrade ablation; retrograde (transaortic) ablation experience is also highly desirable.

Core-level trainees should have a basic knowledge and understanding of the use of pacemakers and ICDs in pediatric and congenital heart patients. In addition, the core trainee should develop an understanding of pacemakers and skills in evaluation of pacemaker problems that may occur. Advanced-level trainees should have advanced knowledge in the evaluation and management of pacemakers and ICDs. In addition, advanced trainees will participate in implantation (either intraoperative evaluation or actual implant depending on whether track 1 or 2 is chosen) of pacemakers and ICDs, and provide expert understanding and management of implanted pacemakers and ICDs. In addition, advanced-level trainees should have an understanding and experience in using pacemakers and ICDs for noninvasive EPS and internal cardioversion. All levels should have skills in introducing temporary transvenous pacemakers. All levels should have experience with transcutaneous pacing. Both levels should have the skill to use transthoracic temporary postoperative epicardial wires for the recording of electrograms. Advanced trainees should have knowledge and experience in using these wires to convert arrhythmias.

Core-level trainees should have a basic understanding of the indications for and use of cardiac surgery to treat arrhythmias. Advanced level trainees should provide expert mapping and other EP knowledge at the surgical procedure.

Specific formal instruction topics should be covered in a core lecture series and in a journal club format. There should be regularly scheduled conferences regarding EPS interpretation, application of the EPS to the patient's clinical management, and conferences on interpretation of standard and ambulatory ECGs.

EVALUATION AND DOCUMENTATION OF COMPETENCE

The program director is expected to maintain adequate records of each individual's training experiences and performance of various procedures for appropriate documentation for levels 1 or 2. The trainees should maintain records of participation in the form of a log book containing clinical information, procedure performed, and outcomes, listing any complications encountered. Finally, formal written evaluations should occur at least every three months.

Track 2 will develop skills in implantation of pacemakers and ICDs, including extraction.

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Task Force 5: Requirements for Pediatric Cardiac Critical Care

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INTRODUCTION

Although pediatric cardiac critical care, as a distinct field of interest, is a relatively recent development, treating critically ill patients has always been a substantial part of clinical pediatric cardiology. In addition, even pediatric cardiologists who do not provide primary care for critically ill patients will be asked to consult on such patients. It therefore seems appropriate to specify what knowledge and skills relevant to the care of critically ill patients should be taught in a pediatric cardiology fellowship program.

FACILITIES AND ENVIRONMENT

Not all pediatric cardiac training programs have a separate pediatric cardiac intensive care unit (ICU), and in some training programs the primary care of hemodynamically compromised cardiac patients is provided by physicians other than pediatric cardiologists. However, this should not preclude trainees from attaining the specified requirements through interaction with pediatric cardiologists, pediatric intensivists, neonatologists, pediatric cardiac surgeons, and other practitioners. Because the advanced practitioner must be board eligible or board certified in pediatric cardiology, it is implied that the pediatric cardiology training be done in an Accreditation Council for Graduate Medical Education (ACGME)-approved training program. The additional nine months of advanced training specified below should take place in an institution in which at least 250 pediatric cardiac procedures per year (this number is by consensus of the authors), utilizing cardiopulmonary bypass, are performed.

LEVELS OF EXPERTISE

In formulating the core training requirements, it was expected that all board-certified pediatric cardiologists should be proficient in the following: 1) the evaluation and (at least) initial stabilization of the hemodynamically compromised pediatric patient with heart disease; and 2) consultation with surgeons, pediatric intensivists, neonatologists, and others regarding the medical, and preoperative and postoperative management of pediatric patients with heart disease.

It is unrealistic to expect all pediatric cardiac trainees to be expert (and stay expert) in the most advanced aspects of pediatric cardiac critical care. In many centers the critical care management of pediatric cardiac patients is provided primarily by pediatric intensivists, neonatologists, or pediatric cardiac surgeons, rather than by cardiologists. However, given that most pediatric cardiologists will occasionally be responsible for situations such as those previously noted, it is important that they can provide appropriate care until consultation with those more experienced in pediatric cardiac intensive care can be obtained. In some cases the pediatric cardiologist may be the only source of expertise (e.g., in understanding the limitations of echocardiography in delineating the anatomy/physiology of a hemodynamically compromised postoperative patient). Hence, it is important that the pediatric cardiologist be familiar with critical care-related issues, often specific to a given cardiac lesion, when providing consultation in the context of the critically ill patient. Thus, *core* requirements apply to *all* trainees seeking board certification in pediatric cardiology.

Advanced requirements, which are more comprehensive, apply to practitioners who will undertake primary responsibility for the comprehensive management of critically ill pediatric patients with congenital or acquired heart disease.

These documents specify training guidelines in pediatric cardiac critical care for pediatric cardiology trainees. The advanced guidelines specify training requirements only for practitioners who are board eligible/board certified in pediatric cardiology. These guidelines do not address what might be a suitable course of training for cardiac critical care for practitioners with primary training in a discipline other than pediatric cardiology.

CORE TRAINING: GOALS AND METHODS

General Requirements

At the end of the pediatric cardiology fellowship, the board-eligible pediatric cardiologist should reliably be able to do the following:

1) Evaluate and treat neonates and infants with critical structural cardiac disease. Evaluation and treatment includes:
   a) Establishing an accurate anatomic diagnosis and ascertaining the relevant cardio-pulmonary physiology.
   b) Providing appropriate medical therapy to stabilize the patient (provide for adequate oxygen delivery and organ perfusion).
   c) Knowing what medical and surgical treatments are appropriate for the condition and what the short- and long-term outcomes of these therapies are.

   In particular, the trainee should have sufficient training and experience to be efficient in managing these patients:
   - Neonates and infants with ductal-dependent left and right-sided obstructive lesions.
   - Neonates with d-transposition of the great arteries.
   - Neonates with total anomalous pulmonary venous connection with obstruction.
   - Infants with anomalous origin of the left coronary artery.
2) Evaluate and treat neonates, infants, and older patients with other forms of critical cardiac disease.

   In particular, the trainee should have sufficient training and experience to be efficient in evaluating and treating these patients:
   - Patients with primary myocardial dysfunction.
   - Patients with acutely compromised cardiopulmonary status due to myocarditis or cardiomyopathy (including that due to rheumatic fever, Kawasaki disease, and so on).
   - Patients with acutely symptomatic arrhythmias.
   - Patients with acutely compromised cardiopulmonary status due to endocarditis.
   - Patients with pericardial effusion.
   - Patients having a hypercyanotic episode ("tet spell").
   - Neonates and infants with increased pulmonary vascular resistance, with or without structural abnormality of the heart.
3) Provide care, or consultation for those providing primary care, for cardiac patients with illness of non-cardiac origin.

   For example, a cyanotic patient with respiratory syncitial virus pneumonitis requires care somewhat different than a patient with a normal heart.
4) Provide consultation for those caring for postoperative cardiac patients.

   In particular, the pediatric cardiologist should be able to do the following:
   - Provide interpretation of diagnostic studies, such as echocardiograms and heart catheterization, including clearly delineating the limitations of such studies.
   - Diagnose and treat acutely symptomatic arrhythmias.
   - Provide consultation regarding therapies to maximize oxygen delivery and cardiac output.
   - Provide consultation regarding pharmacologic and other therapies for patients with "single ventricle" physiology.
   - Provide consultation regarding therapy for patients with increased pulmonary vascular resistance.

SPECIFIC AREAS OF KNOWLEDGE AND COMPETENCE

The following section lists certain areas of special importance.

1. Cardiopulmonary physiology, especially as it applies to cardiac patients in the ICU setting.
   a) Determinants of, and means of influencing, oxygen delivery, cardiac output, and vascular resistance.
   b) The physiology of the patient with a single ventricle, including determinants of, and means of influencing, systemic arterial oxygen saturation, systemic perfusion, and myocardial work.
   c) The physiology of the patient with a ductal-dependent left-sided obstructive lesion, including determinants of, and means of influencing, systemic arterial oxygen saturation, systemic perfusion, and myocardial work.
   d) The physiology of the patient with a fixed restriction of pulmonary blood flow, including determinants of, and means of influencing, systemic arterial oxygen saturation, systemic perfusion, and myocardial work.
   e) The physiology associated with d-transposition of the great arteries.
   f) The physiology of cardiopulmonary interaction, including how mechanical ventilation affects cardiac output.
2. Cardiovascular pharmacology.

   The trainee should learn the actions, mechanisms of action, side effects, and clinical use of:
   a) Inotropic agents (e.g., digoxin, adrenergic agonists, phosphodiesterase inhibitors).
   b) Vasodilators/antihypertensive agents (e.g., alpha adrenergic antagonists, angiotensin-converting enzyme inhibitors, calcium channel antagonists, beta adrenergic antagonists).
   c) Commonly used antiarrhythmic drugs (e.g., digoxin, procainamide, lidocaine, amiodarone).
   d) Inhaled nitric oxide.
   e) Prostaglandin E_1.
   f) Neuromuscular blocking agents (e.g., pancuronium, succinylcholine).
   g) Analgesics and sedatives (e.g., morphine, fentanyl, ketamine, benzodiazepines).

h) Anticoagulants (unfractionated and low molecular weight heparin, warfarin).
i) Diuretics (e.g., furosemide, chlorothiazide).
j) Prostacyclin and other pulmonary vasodilators.

3. The relationship between cardiac structure, function, and clinical state.
   The trainee should learn:
   a) How cardiac structural abnormalities (e.g., obstruction of the atrial septum in hypoplastic left heart syndrome) affect cardiopulmonary function, physiology, and hence the clinical state of the patient.
   b) Methods (e.g., echocardiography, invasive pressure measurements, arterial blood gas analysis, magnetic resonance imaging) to determine and measure cardiac structure, function, and physiology in the ICU patient, and the limitations of these techniques.
   c) Indications for remedy of structural lesions (in both unoperated and operated patients), and appropriate means of therapy (surgical, catheter-based intervention).
4. Diagnosis and therapy of arrhythmias, especially those occurring in ICU patients.
   In particular, the trainee should be familiar with the use of atrial and ventricular pacing leads or transesophageal electrocardiography for diagnosing and treating arrhythmias, and the diagnosis and therapy of junctional ectopic tachycardia.
5. Airway management skills.
6. Provision of analgesia and sedation.
7. Conduct of cardiopulmonary resuscitation.
8. Commonly used modes of mechanical ventilation and their application in patients with heart disease.
9. Common complications that occur in cardiac patients in the ICU, and how they may be prevented and treated.
   The trainee should be familiar with factors that predispose to common postoperative complications (e.g., catheter-related sepsis, pathological thrombosis, surgically-induced heart block), appropriate diagnostic techniques, and therapy for these complications.
10. Familiarity with extracorporeal membrane oxygenation and other cardiac support systems.
11. Indications for, and general principles, for providing "end-of-life" or "palliative" care.

REQUIRED TRAINING PERIOD FOR CORE TRAINING

In training programs where pediatric cardiology fellows provide primary care of pediatric cardiac patients in the ICU (generally programs that have a separate cardiac ICU), a minimum of two months' full-time experience in the ICU is recommended. For programs where pediatric cardiology fellows act as consultants for cardiac patients in the intensive care setting, at least four months' experience providing such consultation is recommended.

Trainees will be evaluated by the appropriate supervising faculty, and both written and oral feedback will be provided to the trainee. Written evaluations, addressing specific areas of competence, will be developed at each training site.

ADVANCED TRAINING: GOALS AND METHODS

Advanced training in pediatric cardiac intensive care is intended to prepare practitioners who will undertake primary responsibility for the comprehensive management of critically ill patients with congenital or acquired heart disease. Because this discipline stands at the nexus of pediatric cardiology and pediatric critical care, some physicians with primary training in fields other than pediatric cardiology work in this area. This document describes an appropriate advanced practitioner training program only for physicians board eligible or board certified in pediatric cardiology; it does not specify what an appropriate training program should be for those trained in other disciplines (e.g., critical care medicine [CCM] or pediatric anesthesiology).

GENERAL REQUIREMENTS

1. The advanced practitioner must be board certified/board eligible in pediatric cardiology.
2. Advanced practitioners must have (at least) nine months of clinical training beyond the core training as outlined in the previous text. (This excludes practitioners doubly boarded in pediatric cardiology and pediatric CCM.) Practitioners with training in (only) pediatric cardiology are therefore expected, in addition to having three years of pediatric cardiology training, to have one month of training in anesthesia, four months' experience predominantly in general pediatric CCM, and at least four months' experience caring for pediatric cardiac patients in the ICU setting (a total of 9 months).

The practitioner must have sufficient experience in managing term and pre-term neonates both preoperatively and postoperatively.

SPECIFIC AREAS OF KNOWLEDGE AND COMPETENCE

Specific requirements for advanced training include all of those for core training (listed in the previous text), as well as the following:

1. Mechanical ventilation.
   a) Indications for and utilization of commonly employed modes of mechanical ventilation, as well as more advanced modes of ventilation (e.g., high-frequency oscillatory ventilation).
   b) Optimal ways of providing gas exchange for patients with congenital heart disease, taking into account factors such as the effect of airway pressure on venous return, the impact of fiO_2 on pulmonary vascular resistance, arterial O_2 saturation, and systemic perfusion.
   c) Pulmonary toxicity related to barotrauma, volutrauma, and high levels of inspired oxygen, and how to minimize such toxicity.
2. Indications for, application of, and complications related to mechanical support for the failing cardiopulmonary system. Current systems that provide such support include extracorporeal life

support, ventricular support devices, and intra-aortic balloon pumps. Expertise in at least one form of mechanical support should result from advanced-level training.
3. Performance of invasive procedures often required in managing critically ill cardiac patients. These procedures include advanced techniques for intravascular access (e.g., subclavian vein and internal jugular venous cannulation), insertion of chest tubes, pericardiocentesis, and so on.
4. Utilization of more advanced cardiovascular pharmacologic therapy (e.g., esmolol for therapy of hypertension, vasopressin for therapy of hypotension).
5. Advanced skills in evaluation and treatment of arrhythmias (e.g., utilization of epicardial electrodes and transesophageal leads for diagnosis and treatment of rhythm abnormalities, use of pharmacologic agents to treat arrhythmias, and so on).
6. Advanced management of pulmonary hypertension.
7. Diagnosis and treatment of less frequently encountered/more complex postoperative complications, including lesion-specific complications. Such complications include significant residual cardiac lesions, paralyzed hemi-diaphragm(s), large airway obstruction, compartment syndrome following femoral arterial cannulation for cardiopulmonary bypass, prolonged chest tube drainage, and so on. The practitioner should be familiar with indications for invasive evaluation (e.g., heart catheterization or bronchoscopy) and invasive therapy (e.g., additional cardiac surgery, interventional catheterization, tracheostomy).
8. Evaluation and management of multisystem organ failure.
9. Postoperative management of orthotopic heart transplant patients, and management of acute rejection.
10. Diagnosis and management of renal failure, including indications for renal replacement therapy.
11. Diagnosis and management of forms of neurological dysfunction, sometimes seen in patients with critical heart disease (seizures, stroke, global ischemia, increased intracranial pressure).
12. Available means of providing nutritional support, and the most appropriate means for a given patient.
13. Transfusion management, and recognition and treatment of common transfusion-related complications.

APPENDIX

Dr. David L. Wessel declared that he had the following relationships with industry relevant to this topic—Pfizer (consultant and research grant); INO Therapeutics (consultant and scientific advisory board). The other authors of this report declared that they have no relationships with industry pertinent to this topic.

Task Force 6: Training in Transition of Adolescent Care and Care of the Adult With Congenital Heart Disease

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INTRODUCTION

The number of adults with congenital heart disease (CHD) has increased significantly over the past 20 years. Palliative surgery and, more recently, non-surgical and medical interventions have permitted even those with the most complex lesions to reach adulthood. The recent Bethesda Conference estimated that there are approximately 420,000 CHD patients in the U.S., based on models that exclude simple congenital lesions such as bicuspid aortic valve, small atrial or ventricular septal defect, and mild pulmonary stenosis. Of those patients, approximately three-fourths have lesions that are moderately complex and one-fourth have lesions of great complexity.

Establishing an adequate system for the care of these individuals is a challenging task that can best be accomplished through an integrative approach that draws on the skills and knowledge base of both pediatric and medical (adult) cardiologists within an adult CHD center. Many adults with CHD continue to be cared for by pediatric cardiologists, who are well trained to deal with the often complex problems associated with CHD, but are generally unprepared to manage unique problems of adults with CHD, including long-term complications and adult health care issues such as pregnancy and overlay of acquired disease. Thus, basic knowledge of issues unique to adults with CHD as well as knowledge of the indications for referral to a specialized adult CHD (ACHD) center is required of all pediatric cardiologists.

The American College of Cardiology (ACC) has published training guidelines for Adult Cardiovascular Medicine Core Cardiology Training II (COCATS 2) which include recommendations regarding care of adult patients with CHD. These recommendations were developed with the recognition that appropriate training and education for adult cardiologists is currently deficient in CHD, but that eventually the numbers and complexity of such adult patients will demand that many be cared for in adult settings by cardiologists with an internal medicine-

adult cardiology background.[1] It will be at least a decade or more before the graduates of adult cardiology training programs are sufficiently numerous and adequately trained to staff specialized adult congenital centers as recommended in the 32nd Bethesda Conference.[2] Medical/pediatric residents with double boards in adult and pediatric cardiology would provide excellent training to care for these patients. Meanwhile, for the foreseeable future, significant numbers of adults will need to receive all or a part of their cardiac care from pediatric cardiologists with training in adult issues.

Even if in the future the majority of adults with CHD are cared for in specialized ACHD centers, staffed primarily by specially trained adult cardiologists, there are compelling reasons for the pediatric cardiology training curriculum to address issues relating to ACHD. The Bethesda Conference recommended that such centers maintain a liaison with pediatric cardiology programs for purposes of patient care, education, and support. For example, as surgical treatments evolve, the postoperative course changes, requiring new forms of surveillance and follow-up; the lessons learned from adolescents will shape the care of adults with CHD, and only close coordination between pediatric cardiologists and specialists in ACHD will optimize that care.

This report suggests an approach to the training of pediatric cardiologists. These guidelines will emphasize the importance of preparing young patients with CHD for transition to adult care, the need for pediatric cardiologists to understand the outcomes of CHD in the adult patient, and will serve as a guide for pediatric cardiologists who will participate directly in the care of adults with CHD.

LEVELS OF TRAINING

Core Training (Level 1)

We differentiate three levels of training and expected expertise in the care of adults with CHD. Core training represents the level of knowledge appropriate for all trainees in pediatric cardiology and indicates the knowledge content that each graduate of such a program should acquire. This level of knowledge should be tested in the Subspecialty Certification Examination in Pediatric Cardiology and will provide the graduate with sufficient expertise to care for adolescents with CHD and prepare them for transition to ACHD care. In addition to the basic science and clinical knowledge included in every pediatric cardiology curriculum, certain additional knowledge areas should be included:

- general knowledge
- natural history of cardiac defects
- postoperative residua, long-term issues
- understanding care in the adult setting
- transition issues
- adolescent medicine
- outpatient experience
- lectures as part of core curriculum
- indications for and access to local/regional expert consultation
- adolescent and young adult medical care issues
- contraception, gynecologic issues, pregnancy
- physical activity, sports, and activity counseling
- education, health and general
- insurability
- employment
- psychosocial issues

Advanced Training (Level 2): Special Expertise in Adults With CHD

The COCATS 2 guidelines for adult cardiology fellows suggest at least one year of concentrated exposure for those trainees who wish to care independently for adult patients with CHD. Certain knowledge areas should be included:

Basic Science

Pathophysiology of acquired heart disease with a strong emphasis on heart failure, arrhythmias, and coronary atherosclerosis.

Adult Medical Care Issues

- coronary artery disease, hypertension, lipid management, chronic obstructive pulmonary disease
- contraception, gynecologic issues, management during pregnancy and delivery
- physical activity, sports, and activity counseling
- education, health and general
- insurability
- employment
- psychosocial issues
- palliative care

In addition to didactic materials, training should include the following activities and aims:

- Participation in a regular (at least weekly) clinic organized for the care of adults with CHD—at least 10 patients per week; and participation in the perioperative care of adult patients with CHD including direct observation of surgical repair.
- Program requirements.

To train effectively at level 2, a pediatric cardiology program should include at least one faculty member with a career commitment to the care of adult patients with CHD.

Advanced Training (Level 3): Advanced Expertise in Adults With CHD

The COCATS 2 guidelines recommend an additional year of continued participation in clinical practice relating to ACHD to achieve advanced level 3 training. In addition to the guidelines for advanced level 2 training, level 3 should include active participation in clinical and/or laboratory research in

conjunction with clinical activities and direct participation in additional cardiac catheterization and echocardiographic procedures in adults with CHD.[1]

APPENDIX

The authors of this section declare they have no relationships with industry pertinent to this topic.

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Task Force 7: Training Guidelines for Research in Pediatric Cardiology

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Historically, pediatric cardiology has been a dynamic clinical field where a rapid transfer of knowledge from the research laboratory to the bedside occurred regularly. Conversely, many problems on which laboratory effort was focused were first identified at the bedside. This pattern continues today, and there is every reason to believe it will accelerate in the future. Research in pediatric cardiology is defined in broad terms because it is anticipated that future advances in the care of pediatric patients with cardiovascular disease will go beyond current practice and come from diverse areas of biomedical science. If the pediatric cardiologist is to maintain clinical competence and improve clinical knowledge in step with the progress of biomedical science, it is crucial that he or she thoroughly understands the concepts, methods, and pitfalls of the research process. It is important that every pediatric cardiology trainee participate directly in research as training that is limited to practical experience can teach only the status quo, and the status quo cannot improve patient care. The guidelines that follow are based in part on recommendations published in 1995 and revised in 2002[1,2] and a Task Force Report on Pediatric Cardiovascular Diseases.[3]

In addition to direct involvement in research, every trainee should gain practical experience in review of published data, research design, data analysis, and logical deduction. The research experience plays a unique role in developing the skills in continuing self-education essential to all pediatric cardiologists. Trainees contemplating a career in investigative cardiology bear a special responsibility to prepare effectively to advance understanding in the broad area of clinical, translational, and basic cardiovascular science as well as population science, behavioral science, quality of care, and outcomes research.

Because the research experience is such an integral component, pediatric cardiology training should be carried out in institutions in which the opportunity to participate in research is available. The training site should be one that provides an atmosphere of intellectual inquiry and support of the investigational process.

GENERAL STANDARDS

The training institution must have staff and facilities for research. Opportunities for research for the trainees should be available not only within the clinical cardiology division, but also within biomedical science, epidemiological, or other clinical programs of the institution. Availability of expertise in cardiac development, cardiovascular genetics, epidemiology, outcome evaluation, biostatistics, population science, behavioral science, quality of care, outcomes research, and biomedical ethics should be readily available. There should be a critical mass of investigators, and it is expected that cardiovascular investigation be well represented. Not all investigators need to be clinical cardiologists, but at least one full-time faculty member from each training program should have demonstrated skill and research productivity as an investigator.

DURATION OF RESEARCH TRAINING

For trainees planning careers in education and patient care, the core research training should include substantial research time devoted to a specific research project or projects. In most cases, this will encompass a full 12 months of the training period. For those planning a career with a major emphasis on investigation, an additional one to two years beyond the core research training, working directly with an experienced funded mentor, is needed in most cases.

CONTENT OF TRAINING PROGRAM

Research training is an important part of the core instruction of every trainee. Those planning a substantive commitment to clinical, translational, or basic cardiovascular research, as well as population science, behavioral science, quality of care, and outcomes research, will need advanced research training.

Core Research Training

It is anticipated that in most instances core research training will be devoted to a specific project or projects with a clinical or translational research focus. Such research training must be carried out under the supervision of an experienced investigator and according to approved principles of biomedical ethics and institutional rules for patient protection. It must be recognized that such research is difficult because of the complexity of achieving valid scien-

tific conclusions while working with a diverse population and simultaneously protecting the interests of each patient. Advanced educational activities as outlined by the American Board of Pediatrics may meet the core research training objectives when appropriately planned, supervised, and evaluated by faculty with expertise in this area.

Components of Core Research Training

With appropriate mentoring, the trainee should develop skills in at least the following areas:

1. Literature study, to ascertain the exact state of knowledge before undertaking new investigation.
2. Formulation of hypothesis and specific goals, ensuring that the hypothesis is testable, that the goals are appropriate, and that statistical power is achievable.
3. Development of the research plan and the protocol, including study design, recruitment of subjects, ethical considerations, informed consent and protection of privacy, data collection modes, full description of procedures, and institutional approval of human investigation, where appropriate.
4. Data collection, including preparation of data forms.
5. Development of analytic methods or procedural skills, as required, and particularly the handling of artifacts, missing data, outliers, and statistical inference.
6. Presentation of results, preferably both oral and written, emphasizing that no investigation is complete until it is reported in peer-reviewed journals.
7. Risk-benefit analysis, regarding both patient (subject) risk and benefit and societal risk and benefit.
8. Health policy implications of research.

In the case of multiple center clinical trials, participation in the full range of special activities outlined here is required. The clinician lacking expertise in these areas may be unable to interpret critical reports bearing directly on his or her practice. New data might be accepted uncritically or important advances recognized tardily. The training program should provide frequent opportunities for faculty and trainees to review and analyze small- and large-scale clinical and basic research reports in depth. Core research training in the eight skill areas in the previous text could be most easily obtained as part of a master's program in Clinical Investigation, Public Health, or some other structured program.

Advanced Research Training

Trainees preparing for research careers in pediatric cardiology need an extensive foundation in scientific investigation. Some trainees may have obtained extensive research preparation in combined MD/PhD programs, but may lack the special skills appropriate to their personal research goals. These may be obtained during a postdoctoral research fellowship or as part of the cardiology traineeship. Advanced research training should be a mentored investigational experience with a productive and active scientist, MD or PhD, working in the appropriate fields of clinical, epidemiological, genetic, developmental, or biomolecular investigation as well as population science, behavioral science, quality of care, and outcomes research.

Trainees who aim for a career in investigative cardiology but who have not had the opportunity to obtain a PhD or equivalent training prior to embarking on their cardiology traineeships should have the opportunity and be encouraged to obtain the essential coursework and laboratory experience necessary for a productive research career. Several types of individual or institutional research training grants are important resources to support such training.

The advanced research training previously outlined constitutes only the beginning of the education of an independent cardiovascular investigator. Individuals who pursue this path will require additional research mentoring as junior faculty, and compensation during the prolonged period of research training and mentoring should be sufficient to allow a substantial time commitment to this training. To prepare for a successful investigative career, mentored training during and following fellowship of two to five years is usually necessary. Current models to support young faculty during these critical times of career development include the American Heart Association Scientist Development Grant and the National Heart, Lung, and Blood Institute K08 or K23 awards.

The fundamental demonstration of successful training for a pediatric cardiology investigator is successful competition for external funding obtained via peer-reviewed mechanisms. Advanced research training plans should be formulated with this goal in mind.

EVALUATION

Evaluation of a trainee's research progress and research skills should be subjective as well as objective, based on agreed-upon criteria and standards, and should be ongoing throughout the training period. Each trainee's competence and understanding should be documented at the completion of training. The American Board of Pediatrics requirements for research oversight should guide the evolution process.

Trainees should be strongly encouraged to publish substantive results, thereby providing an evaluation by peer-reviewed journals.

FLEXIBILITY

It must be appreciated that the education of future investigative cardiologists is a continuing process and that they usually remain in an educational institution where they are immersed in clinical cardiology. They often have unique demands that might require altering the sequence and exposure of clinical training, consistent with their previous clinical experience. Therefore, the program director should be afforded latitude in the assignment of responsibilities for the three years of training while guaranteeing

full clinical competence. Blocked research time of 12 to 18 months with clinical duties limited to one-half day per week plus weekend and night call during this time is highly desirable.

SUMMARY

It is vital to the future intellectual health of cardiovascular medicine and the welfare of pediatric patients with cardiovascular disease that all future pediatric cardiologists be familiar with the principles and tools of research. Training in research requires the intense involvement of productive and established investigators. Those trainees preparing for a career in investigative cardiology require a carefully developed but flexible educational plan that will permit them to be successful in their research careers over an extended period.

APPENDIX

Dr. D. Woodrow Benson declared that he had the following relationships with industry relevant to this topic—stock ownership in Medtronic, Guidant, and Proctor & Gamble. The other authors of this report declared that they have no relationships with industry pertinent to this topic.

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ACC/AHA/AAP RECOMMENDATIONS FOR TRAINING IN PEDIATRIC CARDIOLOGY

AMERICAN COLLEGE OF CARDIOLOGY FOUNDATION, AMERICAN HEART ASSOCIATION and AMERICAN ACADEMY OF PEDIATRICS

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