JOURNAL OF THE AMERICAN COLLEGE OF CARDIOLOGY
© 2015 BY THE SOCIETY OF PEDIATRIC CARDIOLOGY TRAINING PROGRAM DIRECTORS, AMERICAN COLLEGE OF CARDIOLOGY FOUNDATION, AMERICAN ACADEMY OF PEDIATRICS, AND THE AMERICAN HEART ASSOCIATION, INC.
PUBLISHED BY ELSEVIER INC.

VOL. 66, NO. 6, 2015
ISSN 0735-1097/$36.00
http://dx.doi.org/10.1016/j.jacc.2015.03.004

TRAINING STATEMENT

# 2015 SPCTPD/ACC/AAP/AHA Training Guidelines for Pediatric Cardiology Fellowship Programs (Revision of the 2005 Training Guidelines for Pediatric Cardiology Fellowship Programs)

Task Force Members

**Introduction/Steering Committee**
Robert D. Ross, MD, FAAP, FACC, *Chair*
Michael Brook, MD, *Co-Chair*
Peter Koenig, MD, FACC, FASE
Jeffrey A. Feinstein, MD
Peter Lang, MD, FAAP, FACC
Robert L. Spicer, MD, FAAP, FACC
Julie A. Vincent, MD, FAAP, FACC, FSCAI

**Task Force 1: Pediatric Cardiology Fellowship Training in General Cardiology**
Alan B. Lewis, MD, FAAP, FACC, *Co-Chair*
Gerard R. Martin, MD, FAAP, FACC, FAHA, *Co-Chair*
Peter J. Bartz, MD, FASE
Peter S. Fischbach, MD, FACC
David R. Fulton, MD, FAAP, FACC
G. Paul Matherne, MD, MBA, FAAP, FACC, FAHA
Benjamin Reinking, MD, FAAP
Robert L. Spicer, MD, FAAP, FACC

**Task Force 2: Pediatric Cardiology Fellowship Training in Noninvasive Cardiac Imaging**
Shubhika Srivastava, MBBS, FAAP, FACC, FASE, *Co-Chair*
Beth F. Printz, MD, PhD, FAAP, FASE, *Co-Chair*
Tal Geva, MD, FACC
Girish S. Shirali, MBBS, FACC, FASE
Paul M. Weinberg, MD
Pierre C. Wong, MD
Peter Lang, MD, FAAP, FACC

**Task Force 3: Pediatric Cardiology Fellowship Training in Cardiac Catheterization**
Laurie B. Armsby, MD, FAAP, FSCAI, *Co-Chair*
Robert N. Vincent, MD, CM, FACC, FSCAI, *Co-Chair*
Susan R. Foerster, MD, FSCAI
Ralf J. Holzer, MD, FSCAI
John W. Moore, MD, MPH, FAAP, FACC, FSCAI
Audrey C. Marshall, MD
Larry Latson, MD, FAAP, FAAC, FSCAI
Michael Brook, MD

This document was approved by the Society of Pediatric Cardiology Training Program Directors, American Academy of Pediatrics, and the American Heart Association in February 2015 and by the American College of Cardiology in March 2015.

The American College of Cardiology requests that this document be cited as follows: Ross RD, Brook M, Feinstein JA, et al. 2015 SPCTPD/ACC/AAP/AHA training guidelines for pediatric cardiology fellowship programs (revision of the 2005 training guidelines for pediatric cardiology fellowship programs). J Am Coll Cardiol 2015:66:670-1.

This document is copublished in *Circulation*.

Copies: This document is available on the World Wide Web sites of the American College of Cardiology (www.acc.org), American Academy of Pediatrics, (www.aap.org), American Heart Association (my.americanheart.org), and the Society of Pediatric Cardiology Training Program Directors (http://spctpd.com). For copies of this document, please contact the Elsevier Inc. Reprints Department, fax 212-633-3820, e-mail reprints@elsevier.com.



Listen to this manuscript's audio summary by *JACC* Editor-in-Chief Dr. Valentin Fuster.

**Task Force 4: Pediatric Cardiology Fellowship Training in Electrophysiology**
Anne M. Dubin, MD, FHRS, *Co-Chair*
Edward P. Walsh, MD, FHRS, *Co-Chair*
Wayne Franklin, MD, FAAP, FACC, FAHA
Ronald J. Kanter, MD, FACC, FHRS
J. Philip Saul, MD, FACC, FAHA, FHRS
Maully J. Shah, MBBS, FACC, FHRS
George F. Van Hare, MD, FACC, FHRS
Julie A. Vincent, MD, FAAP, FACC, FSCAI

**Task Force 5: Pediatric Cardiology Fellowship Training in Critical Care Cardiology**
Timothy F. Feltes, MD, FAAP, FACC, FAHA, *Co-Chair*
Stephen J. Roth, MD, MPH, FAAP, *Co-Chair*
Melvin C. Almodovar, MD
Dean B. Andropoulos, MD, FAAP
Desmond J. Bohn, MB, BCh, FFARCS, MRCP, FRCPC
John M. Costello, MD, MPH, FAAP
Robert J. Gajarski, MD, MHSA, FAAP, FACC
Antonio R. Mott, MD
Peter Koenig, MD, FACC, FASE

**Task Force 6: Pediatric Cardiology Fellowship Training in Adult Congenital Heart Disease**
Karen Stout, MD, FACC, *Co-Chair*
Anne Marie Valente, MD, FACC, *Co-Chair*
Peter J. Bartz, MD, FASE
Stephen Cook, MD, FACC
Michelle Gurvitz, MD, MS, FACC
Arwa Saidi, MD, FACC
Robert D. Ross, MD, FAAP, FACC

**Task Force 7: Pediatric Cardiology Fellowship Training in Pulmonary Hypertension, Advanced Heart Failure, and Transplantation**
Steven A. Webber, MB, ChB, *Co-Chair*
Daphne T. Hsu, MD, FAAP, FACC, FAHA, *Co-Chair*
D. Dunbar Ivy, MD, FAAP, FACC
Thomas J. Kulik, MD
Elfriede Pahl, MD, FAAP, FACC
David N. Rosenthal, MD
W. Robert Morrow, MD, FAAP, FACC
Jeffrey A. Feinstein, MD

**Task Force 8: Pediatric Cardiology Fellowship Training in Research and Scholarly Activity**
William T. Mahle, MD, FAAP, FACC, FAHA, *Co-Chair*
Anne M. Murphy, MD, FACC, FAHA, *Co-Chair*
Jennifer S. Li, MD
Yuk M. Law, MD, FAAP
Jane W. Newburger, MD, MPH, FACC, FAHA
Stephen R. Daniels, MD, PhD
Daniel Bernstein, MD
Bradley S. Marino, MD, MPP, MSCE, FAAP, FACC, FAHA
Robert D. Ross, MD, FAAP, FACC

JOURNAL OF THE AMERICAN COLLEGE OF CARDIOLOGY
© 2015 BY THE SOCIETY OF PEDIATRIC CARDIOLOGY TRAINING PROGRAM DIRECTORS, AMERICAN COLLEGE OF CARDIOLOGY FOUNDATION, AMERICAN ACADEMY OF PEDIATRICS, AND THE AMERICAN HEART ASSOCIATION, INC.
PUBLISHED BY ELSEVIER INC.

VOL. 66, NO. 6, 2015
ISSN 0735-1097/$36.00
http://dx.doi.org/10.1016/j.jacc.2015.03.007

TRAINING STATEMENT

# 2015 SPCTPD/ACC/AAP/AHA Training Guidelines for Pediatric Cardiology Fellowship Programs (Revision of the 2005 Training Guidelines for Pediatric Cardiology Fellowship Programs): Introduction

Robert D. Ross, MD, FAAP, FACC, *Chair*
Michael Brook, MD, *Co-Chair*
Peter Koenig, MD, FACC, FASE
Jeffrey A. Feinstein, MD
Peter Lang, MD, FAAP, FACC
Robert L. Spicer, MD, FAAP, FACC
Julie A. Vincent, MD, FAAP, FACC, FSCAI

Since the 2005 publication of the first "Training Guidelines for Pediatric Cardiology Fellowship Programs" (1), the field of pediatric cardiology has undergone significant growth and change, and thus, the Society of Pediatric Cardiology Training Program Directors (SPCTPD) in conjunction with the Joint Council of Congenital Heart Disease recommended the guidelines be revised accordingly. The SPCTPD board assembled a Steering Committee that nominated 2 chairs for each of the 8 Task Forces (7 as in the original document plus 1 for "advanced medical therapies," [i.e., heart failure, pulmonary hypertension, and cardiac transplantation]). Six to 8 members were selected from a list of potential committee members representing a wide range of program sizes, geographic regions, and subspecialty focuses. Representatives from the American College of Cardiology, American Academy of Pediatrics, and American Heart Association participated. These participants, along with 1 Steering Committee member, comprised each Task Force. A Steering Committee member was added to provide perspective to each Task Force as a "nonexpert" in that field.

The authors developed the Task Force reports under guidance from the Task Force chairs, approved them for review by individuals selected by the participating organizations, and addressed the 258 comments submitted. The peer reviewers for each report are listed in an appendix in each Task Force report along with their employment information and affiliation in the review process. The final, complete document was approved by the Society of Pediatric Cardiology Training Program Directors, American Academy of Pediatrics, and the American Heart Association in February 2015 and by the American College of Cardiology in March 2015, and individual Task Force reports were endorsed by the organizations noted in each report.

During the process of updating the guidelines, a paradigm shift in medical education occurred. The change to **competency-based training** now requires trainees to achieve an expected level of competency

The American College of Cardiology requests that this document be cited as follows: Ross RD, Brook M, Koenig P, Feinstein JA, Lang P, Spicer RL, Vincent JA. 2015 SPCTPD/ACC/AAP/AHA training guidelines for pediatric cardiology fellowship programs (revision of the 2005 training guidelines for pediatric cardiology fellowship programs): introduction. J Am Coll Cardiol 2015;66:672-6.

This article is copublished in *Circulation*.

in defined tasks (clinical and academic) rather than simply spending a predefined amount of time on a subspecialty service or performing a certain number of procedures to be considered fully "trained." The Task Forces were instead asked to outline the minimum amount of time or number of procedures required so that evaluators can make informed decisions on whether the fellow is competent, and if not, recommend further work in that area. The responsibility will be on the training programs to observe fellows in all aspects of their training and have the newly developed clinical competency committees review their performance and evaluations, and provide feedback on their degree of competency.

The American Board of Pediatrics, the certifying agency of graduating fellows, has directed that the concept of entrustable professional activities (EPAs) be utilized as a framework to identify and evaluate a trainee's ability to independently practice the fundamental professional work that defines our discipline. EPAs are observable and measurable and can be mapped to competencies and milestones across the entire landscape of physician activities from medical school throughout a career of practice. Being entrusted to move on through the fellowship program and to graduate will be determined by fellowship clinical competency committees, the scholastic oversight committees, and the program directors and will serve as the basis for determining board eligibility in the subspecialty.

For each EPA, there are 5 levels of entrustment, which for this document have been modified as follows (2):

Level 1: The fellow has baseline knowledge and skills but is not allowed to perform the EPA independently.

Level 2: The fellow may act under proactive, ongoing, full supervision.

Level 3: The fellow may act under reactive supervision (i.e., the supervisor observes and only participates on request or when the supervisor feels he or she is needed).

Level 4: The fellow may act independently upon graduation.

Level 5: The graduate may act as a supervisor and instructor.

The Accreditation Council of Graduate Medical Education (ACGME) and American Board of Pediatrics (ABP) have worked closely in an effort to identify EPAs that pertain to all pediatric subspecialties, including cardiology. At this time, they have suggested that the following common activities should be achieved by all graduating fellows:

1. Provide for and obtain consultation from other healthcare providers caring for children (see Task Force 1: General Cardiology).
2. Apply public health principles and improvement methodology to improve care for populations, communities, and systems.
3. Lead and work within interprofessional healthcare teams.
4. Facilitate handovers to another healthcare provider including the transition from pediatric to adult health care (see Task Force 6: Adult Congenital Heart Disease).
5. Contribute to the fiscally sound and ethical management of a practice (through billing, scheduling, coding, and record-keeping practices).
6. Engage in scholarly activities through the discovery, application, and dissemination of new knowledge (see Task Force 8: Research).
7. Lead within the subspecialty profession.

Additional EPAs specific for pediatric cardiology delineated by this training statement are:

8. Diagnose and manage congenital or acquired cardiac problems (see Task Force 1: General Cardiology and Task Force 6: Adult Congenital Heart Disease).
9. Diagnose and manage patients with acute congenital or acquired cardiac problems requiring critical care (see Task Force 5: Critical Care Cardiology).
10. Care for patients who require catheter-based intervention (see Task Force 3: Cardiac Catheterization).
11. Diagnose and manage patients with arrhythmias and conduction abnormalities (see Task Force 4: Electrophysiology).
12. Acquire the imaging skills required for all aspects of pediatric cardiology care (see Task Force 2: Noninvasive Cardiac Imaging).
13. Diagnose, initially manage, and refer children with advanced or end-stage heart failure and/or pulmonary hypertension to experts for medical therapy, extracorporeal membrane oxygenation, ventricular assist device, and/or cardiac transplantation (see Task Force 7: Pulmonary Hypertension, Advanced Heart Failure, and Transplantation).

The curricula for these EPAs are delineated for general pediatric cardiology training as well as for all of the subspecialties in the field. Within each Task Force report, the fellow teaching and evaluation process should be designed to foster progression from having basic knowledge and skills (Level 1) to being able to capably perform the particular set of activities independently (Level 4). This will be achieved by using the suggested evaluation tools to grade the specific milestones that describe the levels of ability, and range from novice to expert. All trainees must acquire Level 4 expertise, the ability to act independently, in the core curriculum by the conclusion of the standard pediatric cardiology fellowship program.

**TABLE 1 Core Curricular Competencies and Evaluation Tools Relevant to All Pediatric Cardiology Training**

| |
|---|
| **Medical Knowledge** (see individual task forces for details) |
| **Patient Care and Procedural Skills** (see individual task forces for details) |
| **Systems-Based Practice**<br>■ Coordinate patient care among healthcare providers, including transfer and transition of care.<br>■ Lead a quality improvement project.<br>*Evaluation Tools: conference participation and presentation, direct observation, faculty evaluations, and 360 evaluations* |
| **Practice-Based Learning and Improvement**<br>■ Participate in activities that promote evidence-based learning such as journal clubs and literature reviews.<br>■ Utilize individual learning plans to review previous goals and objectives and plans for the next 3 to 6 months.<br>*Evaluation Tools: meeting with mentors, review by clinical competency committee, and reflection and self-assessment* |
| **Professionalism**<br>■ Practice within the scope of expertise and technical skills.<br>■ Demonstrate a high rate of attendance at fellow conferences.<br>■ Complete procedure logs, duty hour logs, and faculty evaluations in a timely manner.<br>*Evaluation Tools: conference participation and presentation, direct observation, faculty evaluations, and 360 evaluations* |
| **Interpersonal and Communication Skills**<br>■ Function as an effective communicator within a multidisciplinary team.<br>■ Engage in shared decision making with patients and their families, including options for diagnosis and treatment.<br>■ Participate in end-of-life patient care plans.<br>*Evaluation Tools: direct observation, faculty evaluations, and 360 evaluations* |

Lifelong learning skills must then be fostered so that growth continues after successful completion of formal training. Fellows are not expected to reach Level 5 expertise, the competency to act as a supervisor or instructor, for EPAs upon graduation, but they will continue to strive toward Level 5 expertise throughout their career, particularly in their areas of interest. Training programs will be responsible for attesting to the certifying boards and the public that trainees have these capabilities and skills.

The format of these revisions conforms to the original version, in which core training concentrates on what is expected of fellows going through the standard 3 years of fellowship training in an ACGME-accredited institution. This is followed by an outline of advanced training that delineates what is entailed for a fellow who continues training beyond the 3 years to obtain subspecialty expertise. Some subspecialties have documented advanced training elsewhere, and some have developed examinations for graduates. There are no such examinations provided by the ABP for advanced certification in pediatric cardiology training, although the ABP does sanction the American Board of Internal Medicine examination in adult congenital heart disease for qualified pediatric cardiology graduates who complete the requisite adult cardiology training.

As in residency training, fellows are required to be proficient in the 6 core competency domains delineated by the ACGME in each of the pediatric cardiology subspecialties (3). The differences between residency and fellowship are most evident in the medical knowledge and the patient care and procedural skills components that are the main foci of each Task Force report. The additional 4 ACGME competency domains—systems-based practice, practice-based learning and improvement, professionalism, and interpersonal and communication skills—are also important to pediatric cardiology training and are highlighted in all areas of Table 1. All competencies are accompanied by a list of evaluation tools suitable for assessment of competence.

Many Task Forces discuss participation in the quality improvement process as trainees rotate on the particular subspecialty service. The expectation is that the fellows participate by attending quality assurance meetings and mortality and morbidity conferences, but they need only initiate 1 quality improvement project during their core training that they see to completion in any area of pediatric or adult/congenital cardiology.

The curriculum outlined by each Task Force and the milestones listed delineate the knowledge and skills that each fellow should achieve by completion of the 3 years of core fellowship training. Careful monitoring and mentoring of each fellow along the way should ensure that these goals are achieved. This process should culminate in a senior fellow demonstrating confidence in the ability to care for all varieties of patients encountered in the field of pediatric cardiology and strong progress in the particular subspecialty area of interest. This frequently is tested by having an "Acting Attending" month toward the end of the fellowship, where fellows lead the inpatient service and the teaching of residents and junior fellows under the watchful eye of the faculty, who are there for support and consultation.

**ACKNOWLEDGMENT** The Steering Committee would like to acknowledge the diligent work and guidance in the preparation of this manuscript of Dawn R. Phoubandith, MSW, Director, Competency Management, American College of Cardiology.

## REFERENCES

**1.** Graham TP Jr, Beekman RH III. ACCF/AHA/AAP recommendations for training in pediatric cardiology: training guidelines for pediatric cardiology fellowship programs. J Am Coll Cardiol. 2005;46:1380–1.

**2.** ten Cate O, Snell L, Carraccio C. Medical competence: the interplay between individual ability and the health care environment. Med Teach. 2010;32:669–75.

**3.** Accreditation Council for Graduate Medical Education. ACGME program requirements for graduate medical education in pediatric cardiology. Available at: http://www.acgme.org/acgmeweb/Portals/0/PFAssets/2013-PR-FAQ-PIF/325_cardiology_peds_07012013.pdf. Accessed September 23, 2014.

**KEY WORDS** SPCTPD/ACC/AAP/AHA Training Statement, clinical competence, fellowship training, pediatric cardiology, quality improvement

## APPENDIX 1. AUTHOR RELATIONSHIPS WITH INDUSTRY AND OTHER ENTITIES (RELEVANT)—2015 SPCTPD/ACC/AAP/AHA TRAINING GUIDELINES FOR PEDIATRIC CARDIOLOGY FELLOWSHIP PROGRAMS: INTRODUCTION

| Committee Member | Employment | Consultant | Speakers Bureau | Ownership/ Partnership/ Principal | Personal Research | Institutional/ Organizational or Other Financial Benefit | Expert Witness |
|---|---|---|---|---|---|---|---|
| Robert D. Ross *(Chair)* | Children's Hospital of Michigan, Wayne State University School of Medicine—Director of Fellowship Programs and The Pulmonary Hypertension Program | None | None | None | None | None | None |
| Michael Brook *(Co-Chair)* | University of California-San Francisco—Professor of Pediatrics; Director of Pediatric Echocardiography; Director of Pediatric Cardiology Fellowship Training | None | None | None | None | None | None |
| Jeffrey A. Feinstein | Stanford University—Professor, Pediatrics and by courtesy BioEngineering; Lucile Packard Children's Hospital, Stanford—Director, Pediatric Pulmonary Hypertension Service, Dunlevie Family Chair in Pulmonary Vascular Disease | None | None | None | None | None | None |
| Peter Koenig | Ann & Robert H. Lurie Children's Hospital of Chicago—Pediatric Cardiology Fellowship Director; Northwestern University Feinberg School of Medicine—Associate Professor of Pediatrics | None | None | None | None | None | None |
| Peter Lang | Boston Children's Hospital—Senior Associate in Cardiology; Director Emeritus, Fellowship Training Program in Pediatric Cardiology and Cardiovascular Research; Harvard Medical School—Associate Professor of Pediatrics | None | None | None | None | None | None |
| Robert L. Spicer | University of Nebraska and Creighton University Schools of Medicine—Professor of Pediatrics; Children's Hospital & Medical Center—Chief of Cardiology | None | None | None | None | None | None |
| Julie A. Vincent | Columbia University, College of Physicians and Surgeons—Division Chief, Pediatric Cardiology; Welton M Gersony Associate Professor of Pediatric Cardiology; Associate Professor of Pediatrics at CUMC; New York-Presbyterian Hospital—Director, Pediatric Interventional Cardiology | None | None | None | None | None | None |

For the purpose of developing a general cardiology training statement, the American College of Cardiology (ACC) determined that no relationships with industry (RWI) or other entities were relevant. This table reflects authors' employment and reporting categories. To ensure complete transparency, authors' comprehensive healthcare-related disclosure information—including RWI not pertinent to this document—is available in an online data supplement. Please refer to http://www.acc.org/guidelines/about-guidelines-and-clinical-documents/relationships-with-industry-policy for definitions of disclosure categories, relevance, or additional information about the ACC Disclosure Policy for Writing Committees.

## APPENDIX 2. PEER REVIEWER RELATIONSHIPS WITH INDUSTRY AND OTHER ENTITIES (RELEVANT)—2015 SPCTPD/ACC/AAP/AHA TRAINING GUIDELINES FOR PEDIATRIC CARDIOLOGY FELLOWSHIP PROGRAMS: INTRODUCTION

| Name | Employment | Representation | Consultant | Speakers Bureau | Ownership/ Partnership/ Principal | Personal Research | Institutional/ Organizational or Other Financial Benefit | Expert Witness |
|---|---|---|---|---|---|---|---|---|
| Dianne Atkins | University of Iowa—Division of Pediatric Cardiology | AHA | None | None | None | None | None | None |
| Antonio Cabrera | Texas Children's Hospital—Pediatric Cardiology | AAP | None | None | None | None | None | None |
| Bruce Gelb | Mount Sinai Medical Center—Professor, Pediatrics | AHA | None | None | None | None | None | None |
| Seema Mital | Hospital for Sick Children—Pediatric Cardiology | AHA | None | None | None | None | None | None |
| Sara Pasquali | University of Michigan Health System—Associate Professor of Pediatrics | AAP | None | None | None | None | None | None |
| Swee Chye Quek | National University of Singapore, Department of Pediatrics | ACC ACPC Council | None | None | None | None | None | None |
| Jonathan Rome | Children's Hospital of Philadelphia | AHA | None | None | None | None | None | None |
| Craig Sable | Children's National Medical Center—Training Director | AHA | None | None | None | None | None | None |
| Timothy Slesnick | Emory University—Assistant Professor, Pediatric Cardiology | AHA | None | None | None | None | None | None |
| Eric S. Williams | Indiana University School of Medicine—Professor (Cardiology) and Associate Dean; Indiana University Health, Cardiology Service Line Leader | ACC CMC Lead Reviewer | None | None | None | None | None | None |

For the purpose of developing a general cardiology training statement, the ACC determined that no relationships with industry or other entities were relevant. This table reflects peer reviewers' employment, representation in the review process, as well as reporting categories. Names are listed in alphabetical order within each category of review. Please refer to http://www.acc.org/guidelines/about-guidelines-and-clinical-documents/relationships-with-industry-policy for definitions of disclosure categories, relevance, or additional information about the ACC Disclosure Policy for Writing Committees.

AAP indicates American Academy of Pediatrics; ACC, American College of Cardiology; ACPC, Adult Congenital and Pediatric Cardiology; AHA, American Heart Association; and CMC, Competency Management Committee.

JOURNAL OF THE AMERICAN COLLEGE OF CARDIOLOGY
VOL. 66, NO. 6, 2015

PUBLISHED BY ELSEVIER INC.
ISSN 0735-1097/$36.00
http://dx.doi.org/10.1016/j.jacc.2015.03.009

TRAINING STATEMENT

# Task Force 1: Pediatric Cardiology Fellowship Training in General Cardiology

Alan B. Lewis, MD, FAAP, FACC, *Co-Chair*
Gerard R. Martin, MD, FAAP, FACC, FAHA, *Co-Chair*
Peter J. Bartz, MD, FASE
Peter S. Fischbach, MD, FACC
David R. Fulton, MD, FAAP, FACC
G. Paul Matherne, MD, MBA, FAAP, FACC, FAHA
Benjamin Reinking, MD, FAAP
Robert L. Spicer, MD, FAAP, FACC

## 1. INTRODUCTION

### 1.1. Document Development Process

The Society of Pediatric Cardiology Training Program Directors (SPCTPD) board assembled a Steering Committee that nominated 2 chairs, 1 SPCTPD Steering Committee member, and 5 additional experts from a wide range of program sizes, geographic regions, and subspecialty focuses. Representatives from the American College of Cardiology (ACC), American Academy of Pediatrics (AAP), and American Heart Association (AHA) participated. The Steering Committee member was added to provide perspective to each Task Force as a "nonexpert" in that field. Relationships with industry and other entities were not deemed relevant to the creation of a general cardiology training statement; however, employment and affiliation information for authors and peer reviewers are provided in Appendixes 1 and 2, respectively, along with disclosure reporting categories. Comprehensive disclosure information for all authors, including relationships with industry and other entities, is available as an online supplement to this document.

The writing committee developed the document, approved it for review by individuals selected by the participating organizations (Appendix 2), and addressed the comments. The final document was approved by the SPCTPD, AAP, and AHA in February 2015 and approved by the ACC in March 2015. This document is considered current until the SPCTPD revises or withdraws it.

### 1.2. Background and Scope

The goals of pediatric cardiology training include the acquisition of cognitive and procedural expertise needed to provide high-quality care to the fetus, infant, and child with congenital and acquired cardiovascular disease and the adult with congenital heart disease, along with the acquisition of the academic skills to make meaningful scholarly contributions to the specialty and to develop the capacity for career-long self-education beyond the years of formal training (1). The 2005 training guidelines emphasized the "time" (i.e., the number of months or procedures) devoted to a particular "topic." Since then, competency-based training has become the general framework for medical education and is utilized in this report.

Our revised training recommendations describe the program resources and environment that are required for training pediatric cardiology fellows, together with a competency-based system promulgated by the Accreditation Council of Graduate Medical Education (ACGME), to implement specific goals and objectives

The American College of Cardiology requests that this document be cited as follows: Lewis AB, Martin GR, Bartz PJ, Fischbach PS, Fulton DR, Matherne GP, Reinking B, Spicer RL. Task force 1: pediatric cardiology fellowship training in general cardiology. J Am Coll Cardiol 2015;66:677–86.

This article is copublished in *Circulation*.

for training pediatric cardiology fellows. This system categorizes competencies into 6 core competency domains: Medical Knowledge, Patient Care and Procedural Skills, Systems-Based Practice, Practice-Based Learning and Improvement, Professionalism, and Interpersonal and Communication Skills, along with identification of suggested evaluation tools for each domain. Competencies unique to general pediatric cardiology training, along with suggested evaluation tools, are listed in Section 3 (see the "2015 SPCTPD/ACC/AAP/AHA Training Guidelines for Pediatric Cardiology Fellowship Programs [Revision of the 2005 Training Guidelines for Pediatric Cardiology Fellowship Programs]: Introduction" for additional competencies and evaluation tools that apply to all Task Force reports).

The training of pediatric cardiology fellows builds on the clinical and academic skills acquired during residency training. Pediatric cardiology fellows should have a broad exposure to the spectrum of inpatient, outpatient, and consultative activities as outlined in the following text, including cardiovascular manifestations of other organ system disorders and preventive cardiology.

### 1.3. Levels of Expertise—Core and Advanced

In the 2015 SPCTPD/ACC/AAP/AHA Training Guidelines for Pediatric Cardiology Fellowship Programs, both *core training* and *advanced training* are identified for fellows across each specialty area. *Core training* is the basic training required of all fellows to become competent consulting pediatric cardiologists and can be accomplished during the standard 3-year pediatric cardiology fellowship training. *Advanced training* guidelines are recommended for fellows who wish to become proficient in a particular field within pediatric cardiology and/or perform or interpret specific diagnostic tests and procedures or render specialized care for specific patients and conditions. Training in general pediatric cardiology represents the foundational training upon which all subspecialized, advanced, and procedure-oriented training is based. Accordingly, all training delineated in this report is core to fellowship training, required for all trainees, and intended to ensure that fellows acquire the knowledge and skills necessary to become a competent consulting pediatric cardiologist.

## 2. PROGRAM RESOURCES AND ENVIRONMENT

### 2.1. General Environment

The fundamental goal of clinical pediatric cardiology training is to allow trainees to acquire the diagnostic skills (competencies) necessary to provide optimal inpatient, outpatient, and consultative care to the fetus, infant, and child with cardiovascular disease and young adult with congenital heart disease. This requires the assimilation of data from multiple sources and high-level critical thinking and decision making that is derived from direct patient care. The fundamental skills of history taking and physical examination form the basis for correctly initiating the diagnostic and management options appropriate for the individual patient. These skills must be stressed at all points of patient contact. Teaching faculty should observe fellows performing the key elements of history and physical examination to rate the fellow's progress in acquiring these skills. Similarly, fellows should have the opportunity to observe faculty in this activity. Outpatient clinics, inpatient units, and consultation services all provide excellent opportunities for such training and interaction.

Participation in an outpatient cardiology continuity clinic should occur throughout the entire period of training to develop an understanding of the progression of cardiac disease and its cumulative medical and social impact on patients and families. In addition to general pediatric cardiology, the outpatient experience should include patients with heart transplantation, pulmonary hypertension, rhythm disorders, and pacemakers. Fellows should receive at least 4 months of general inpatient cardiology training, although 6 months of experience is encouraged. Both inpatient and outpatient experiences should include exposure to the management of the young adult with congenital heart disease.

### 2.2. Core Curriculum

During the course of inpatient and outpatient activities, the pediatric cardiology fellow will acquire understanding and familiarity with the content of the core knowledge base. The tabulation in this document, although comprehensive, should not be viewed as an encyclopedic summary of all that is required; rather, it serves as an outline of the medical knowledge and skills needed to become entrusted with the care of pediatric cardiology patients. The fellowship 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 should be provided and should include a multidisciplinary core curriculum in scholarly activities as mandated by the American Board of Pediatrics. Pediatric cardiology fellows should contribute formal presentations of selected topics in the core curriculum to strengthen their knowledge base and develop formal presentation skills. Fellows should have the opportunity to examine pathology specimens of normal and abnormal hearts under the supervision and guidance of a pediatric cardiologist or pathologist with specific background and training in congenital heart disease.

Correlation of pathological anatomy with imaging procedures such as echocardiography, cardiac angiography, and cardiac magnetic resonance imaging (MRI) should be incorporated into the pathology review.

Cardiovascular surgical, cardiac catheterization/intervention, electrophysiology, and echocardiography conferences should be regularly scheduled. Journal club is a necessary element for establishing an academic and scholarly environment, and provides an excellent opportunity for the critical evaluation of study design and data analysis of publications, as well as enhancing a commitment to keep up with advances in medical knowledge and evidence-based patient care. Quality assurance, patient safety, and morbidity/mortality conferences should be held at appropriate intervals. Multidisciplinary clinical and research conferences are strongly encouraged, and according to the resources of individual institutions may include cardiothoracic surgery, neonatology, adult cardiology, pulmonology, pathology, physiology, pharmacology, intensive care, cardiac anesthesiology, radiology, genetics, developmental biology, immunology, and stem cell biology. In all of these conferences, pediatric cardiology fellows should be provided the opportunity of active participatory roles appropriate to their level of knowledge and training.

### 2.3. Teaching and Evaluation Skills

Pediatric cardiology fellows should be afforded teaching opportunities in formal and informal settings. These include bedside teaching of medical students, pediatric interns, and residents on the inpatient and outpatient services, as well as lectures and seminars to pediatric residents and other subspecialty groups. The pediatric cardiology fellow must be given adequate opportunities to practice clinical and administrative leadership and organizational skills appropriate for his/her level of knowledge, training, and experience. Observation and critique of these skills by faculty cardiologists are necessary components for growth and improvement in these areas.

## 3. CORE TRAINING: GOALS AND METHODS

The core clinical knowledge and experience for general inpatient and outpatient cardiology required for all pediatric cardiology trainees is summarized in the following text. Each clinical area is subdivided according to ACGME competency domain. Suggested evaluation tools to assess competency in each domain are shown in Section 3.10. Please refer to Task Force 4: Pediatric Cardiology Fellowship Training in Electrophysiology for information on evaluating and managing pediatric patients with supraventricular tachycardia. Please refer to Task Force 6: Pediatric Cardiology Fellowship Training in Adult Congenital Heart Disease regarding transition from pediatric to adult congenital heart disease care.

### 3.1. Evaluation and Management of the Cyanotic Newborn

#### MEDICAL KNOWLEDGE

- Know the appropriate, prioritized differential diagnosis for a cyanotic newborn including noncardiac causes.
- Know the unique physiology and differences between complete transposition of great arteries and tetralogy of Fallot.
- Know the natural history of the disease process (with and without intervention).
- Know the physiology of cyanosis including the relationship between cyanosis, oxygen saturation, $pO_2$, and oxygen hemoglobin dissociation curve, as well as the effect that hemoglobin concentration has on the appearance of cyanosis.
- Know the risks, benefits, and indications for intervention including neonatal palliative shunt, neonatal intracardiac repair, delayed intracardiac repair, or catheter-based intervention.

#### PATIENT CARE AND PROCEDURAL SKILLS

- Have the skills to obtain an appropriate history and physical examination and to recognize maternal, fetal, and familial risk factors that may predispose to cyanotic congenital heart disease (2).
- Have the skills to develop appropriate initial management plans based upon physiology, including recognizing ductal-dependent lesions and utilizing $PGE_1$ appropriately; awareness of indications for neonatal atrial septostomy; utilizing appropriate pharmacological agents to optimize pulmonary and systemic circulation (inotropic support, systemic and pulmonary vasodilators); and utilizing appropriate monitoring and diagnostic testing to direct medical management (e.g., cardiac monitoring, systemic monitoring, cerebral oxygen saturation monitors, lactate and mixed systemic venous oxygen saturation [$SVO_2$]).

#### SYSTEMS-BASED PRACTICE

- Coordinate interdisciplinary outpatient management team including primary care physician, nursing, nutrition, and social services.
- Utilize appropriate and cost-effective diagnostic testing, including arterial blood gases, chest x-ray, electrocardiogram (ECG), echocardiogram, cardiac catheterization, computed tomography, or MRI and know their limitations and risks.

#### PROFESSIONALISM

- Respond appropriately in emergency situations by recognizing limitations and seeking assistance when needed.

INTERPERSONAL AND COMMUNICATION SKILLS

- Effectively communicate management plans with other specialty services including intensive care and surgical teams.
- Communicate with and counsel patients' families regarding immediate and long-term management.

### 3.2. Evaluation and Management of Left-to-Right Shunts

MEDICAL KNOWLEDGE

- Know the anatomy of the atrial septum and correlations between pathologic specimen, clinical presentation, and diagnostic tests (echocardiography and angiography).
- Know the types of atrial septal defects based on location.
- Know the anatomy of the ventricular septum and correlations between pathologic specimen, clinical presentation, and diagnostic tests (echocardiography and angiography).
- Know the types of ventricular septal defects (VSDs) based on location.
- Know the pathophysiology and natural history of left-to-right shunt lesions, including spontaneous closure of VSDs and the effect of changes in pulmonary and systemic vascular resistance on shunt flow.
- Know the mechanisms of action, risks/benefits, and appropriate utilization of pharmacological agents in the management of left to right shunts (e.g., diuretics, angiotensin-converting enzyme inhibitors, and digoxin).
- Know the indications and timing of surgical or catheter intervention based on lesion.

PATIENT CARE AND PROCEDURAL SKILLS

- Have the skills to obtain a detailed history regarding symptoms suggestive of heart failure, including respiratory status, feeding intolerance, diaphoresis with feeding, and growth.
- Have the skills to identify signs associated with various shunt lesions, including vital signs, respiratory status, precordial impulse, thrill, pulmonic component of second heart sound, systolic/diastolic/continuous murmurs (frequency/pitch, duration, quality, location, and radiation), rales, hepatomegaly, femoral pulses, and perfusion.
- Have the skills to interpret ECG with recognition of QRS axis, atrial enlargement, right ventricular hypertrophy (RVH), and left ventricular hypertrophy (LVH).
- Have the skills to consider need for chest x-rays based on age of patient, findings on examination, and suspicion for a pulmonic process.
- Have the skills to perform and interpret echocardiograms for presence of atrial septal defects (ASD) (location, size), VSD (location, size, left ventricular [LV]-right ventricular [RV] gradient), patent ductus arteriosus (PDA) (size, aortic-pulmonary artery [Ao-PA] gradient), LV size and function, RV size, and pulmonary hypertension. Know when sedation is required and when an alternate imaging modality is necessary.

SYSTEMS-BASED PRACTICE

- Order appropriate diagnostic testing and design management plans in a cost-effective manner.
- Set appropriate intervals for follow-up assessment.

INTERPERSONAL COMMUNICATION AND SKILLS

- Explain surgical and/or catheter intervention to family including benefits/risks, anticipated course, and post-intervention follow-up.
- Explain clinical status to family, reasons for additional testing, and the need for pharmacological agents or hospital admission based on clinical status.

### 3.3. Evaluation and Management of Right and Left Heart Obstructive Lesions

MEDICAL KNOWLEDGE

- Know the pathophysiology and natural history of valvar, subvalvar, and supravalvar aortic and pulmonic stenosis, coarctation of aorta, and bicuspid aortic valve.
- Know the indications for surgical or catheter intervention based on lesion.

PATIENT CARE AND PROCEDURAL SKILLS

- Have the skills to obtain detailed age-appropriate history regarding symptoms, including respiratory status, feeding intolerance, diaphoresis with feeding, growth, exercise intolerance, and chest pain.
- Have the skills to identify physical examination signs associated with various obstructive lesions, including upper and lower extremity blood pressure differences, respiratory status, precordial impulse, thrill, ejection clicks, murmurs (frequency/pitch, duration, quality, location, and radiation), femoral pulses, and perfusion.
- Have the skills to interpret ECG with recognition of QRS axis, RVH, LVH, ST, and T-wave abnormalities.
- Have the skills to perform and interpret echocardiogram for presence of valvar (subvalvar and supravalvar) aortic or pulmonic stenosis, bicuspid aortic valve, and coarctation of aorta.
- Have the skills to recognize ductal-dependent critical right or left heart obstruction in the neonate and initiate treatment with $PGE_1$, and recognize when $PGE_1$ therapy may be detrimental (e.g., pulmonary venous obstruction).

SYSTEMS-BASED PRACTICE

- Order appropriate diagnostic testing and designs management plans in a cost effective manner.
- Coordinate care with surgical or interventional team and primary care provider.
- Set appropriate intervals for follow-up assessment.

INTERPERSONAL COMMUNICATION AND SKILLS

- Explain clinical status to family including reasons for additional testing and intervention.
- Explain surgical and/or catheter intervention to family including benefits/risks, anticipated course, and post-intervention follow-up.
- Advise patient and family on appropriate levels of sports and competitive athletic participation.

### 3.4. Evaluation and Management of Cardiomyopathies

MEDICAL KNOWLEDGE

- Know the natural history of dilated, hypertrophic, and restrictive cardiomyopathy, including the risk for sudden cardiac death (3).
- Know the importance of obtaining a thorough family history and how to utilize genetic testing where appropriate (4) and cost effective.
- Know the indications, benefits, and risks of pharmacological agents in the management of:
  - Dilated cardiomyopathy: diuretics, angiotensin-converting enzyme inhibitors, beta-adrenergic antagonists, spironolactone, and digoxin.
  - Hypertrophic cardiomyopathy: beta-blockers, non-dihydropyridine calcium channel blockers (e.g., verapamil), and disopyramide.
- Know the indications for septal myotomy/myectomy in hypertrophic cardiomyopathy and implantable cardioverter-defibrillator.
- Know the appropriate limitations and restrictions to physical activities and sports participation.

PATIENT CARE AND PROCEDURAL SKILLS

- Have the skills to obtain an appropriate history and physical examination.

SYSTEMS-BASED PRACTICE

- Coordinate patient care management plan with heart transplant and electrophysiology teams.
- Order appropriate noninvasive and invasive diagnostic modalities in an efficient and cost-effective manner, and know how to interpret correctly: ECG, echocardiogram, Holter monitor, treadmill stress testing, MRI, cardiac catheterization, and endomyocardial biopsy (5).

INTERPERSONAL AND COMMUNICATION SKILLS

- Communicate diagnosis, management plans, prognosis, and familial implications with patient, family, and primary care physician, and counsels child and family about physical activity and sports participation.

### 3.5. Evaluation and Management of Chest Pain in Children and Adolescents

MEDICAL KNOWLEDGE

- Know the cardiac and noncardiac causes of chest pain in children and adolescents (6).
- Know the potential contributions and limitations of specific tests to address clinical possibilities suggested by the differential diagnosis.
- Know the costs and benefits relative to the likelihood of detecting abnormalities of obtaining an ECG, chest x-ray, echocardiogram, Holter/event monitoring, and exercise testing.

PATIENT CARE AND PROCEDURAL SKILLS

- Have the skills to elicit pertinent history regarding the characteristics of symptoms (e.g., exertional versus nonexertional pain).
- Have the skills to identify contributing family history of sudden death, aborted sudden death, hyperlipidemia, or pulmonary hypertension.
- Have the skills to perform physical examination with emphasis on cardiac aspects of examination.
- Have the skills to formulate a differential diagnosis, including possible cardiac and noncardiac etiologies.

SYSTEMS-BASED PRACTICE

- Obtain subspecialty evaluation (e.g., gastroenterology and pulmonary), when indicated.

INTERPERSONAL COMMUNICATION AND SKILLS

- Summarize the findings with the patient and family with explanation of symptoms and reasons for any proposed testing.
- Review results of tests with patient and family. In the case of a cardiac etiology, discuss implications, plan for further work-up, and treatment/intervention as needed.
- Appropriately reassure patient/family about benign, noncardiac chest pain.

### 3.6. Evaluation and Management of Syncope (7)

MEDICAL KNOWLEDGE

- Know the pathophysiology of neural-mediated or vasovagal syncope.
- Know the nonpharmacological management including fluid/salt supplementation and injury avoidance.

- Know evidence-based indications/limitations for pharmacological management (e.g., midodrine, beta-adrenergic antagonists, and fludrocortisone), including mechanism of action, dosage, frequency, and untoward effects.

PATIENT CARE AND PROCEDURAL SKILLS

- Have the skills to obtain a detailed history regarding the nature of episodes, triggers, postural change, frequency, duration, recovery, pre-syncopal events, and fluid intake.
- Have the skills to inquire about pertinent family history.
- Have the skills to detect abnormalities on physical examination, including measuring vital signs during orthostatic maneuvers.
- Have the skills to interpret ECG with emphasis on findings supporting a cardiac etiology, including a long QT interval or conduction abnormalities (8).
- Have the skills to assemble a differential diagnosis based on history and physical examination to consider cardiac, neurological, or neural-mediated etiology.
- Have the skills to order further cardiac testing as appropriate, including Holter/event monitoring, exercise testing, echocardiography, tilt table testing, and MRI.
- Have the skills to recognize the need for neurological or psychiatric consultation based on history.

SYSTEMS-BASED PRACTICE

- Refer for electrophysiological evaluation when indicated from history, ECG, and/or Holter/event monitoring.

INTERPERSONAL COMMUNICATION AND SKILLS

- Discuss potential causes with patient/family, including mechanisms leading to syncope that is neural-mediated versus cardiac in origin, and explain indications for further testing if indicated.

### 3.7. Evaluation and Management of Hypercholesterolemia and Other Dyslipidemias

MEDICAL KNOWLEDGE

- Know the pediatric origins of coronary heart disease in the adult.
- Know the role of diet and lifestyle in prevention of coronary heart disease.
- Know the genetic basis of familial hypercholesterolemia.
- Know the indications, mechanisms of action, benefits, and risks of pharmacological agents for treatment of dyslipidemia in children with familial hypercholesterolemia, metabolic syndrome, or diabetes mellitus, including bile acid sequestrants, statins, ezetimibe, niacin, fibrates, and omega-3 fatty acids.

PATIENT CARE AND PROCEDURAL SKILLS

- Have the skills to obtain a detailed family history and recommend screening of appropriate family members and recognize other systemic etiologies of hyperlipidemia (e.g., hypothyroidism and renal failure).
- Have the skills to assess the increased risk of coronary heart disease in patients with familial hypercholesterolemia, metabolic syndrome, and diabetes mellitus.
- Have the skills to formulate an individualized management plan based upon current cholesterol screening guidelines and recommendations for dietary and lifestyle modification and pharmacological treatment (9).
- Obtain subspecialty evaluation (e.g., endocrinology, gastroenterology) when indicated.

SYSTEMS-BASED PRACTICE

- Work with family and insurers to minimize the financial implication of long-term use of pharmacological agents.

INTERPERSONAL COMMUNICATION AND SKILLS

- Counsel and refer patients for management of overweight and obesity.
- Counsel family about the individual and familial implications of hyperlipidemia and the need for family-wide lifestyle and dietary modifications.

### 3.8. Evaluation and Management of Kawasaki Disease

MEDICAL KNOWLEDGE

- Know the differential diagnosis for an acute febrile illness mimicking Kawasaki disease.
- Know the symptoms, clinical findings, and course of Kawasaki disease, including atypical presentation.
- Know the tests to support the clinical diagnosis of Kawasaki disease including ECG, echocardiogram, complete blood count (CBC) with differential, platelets, erythrocyte sedimentation rate (ESR), C-reactive protein (CRP), Na, and albumin.
- Know the indications, risks, and benefits of pharmacological agents during all phases of illness, including intravenous immunoglobulin (IVIG), aspirin, corticosteroids, heparin, and warfarin.
- Know the incidence and natural history of coronary artery aneurysms, including giant aneurysm development in untreated and treated patients.
- Know the indications for retreatment with IVIG and alternative therapies in the setting of IVIG resistance.
- Know of tailored therapy for patients with residual coronary artery lesions.

PATIENT CARE AND PROCEDURAL SKILLS

- Have the skills to obtain detailed history of the acute illness with respect to the symptoms and signs of classical Kawasaki disease.
- Have the skills to identify pertinent findings on physical examination necessary to arrive at clinical diagnosis.
- Have the skills to interpret echocardiograms with emphasis on recognition of normal coronary artery anatomy and potential changes involving coronaries, LV function, mitral regurgitation, and pericardial effusion, and to know when alternate imaging modalities should be obtained.
- Have the skills to synthesize clinical information to arrive at a likely diagnosis of Kawasaki disease, including incomplete or atypical Kawasaki disease.
- Have the skills to identify and develop treatment plans for patients with atypical Kawasaki disease or persistent fever despite treatment with intravenous immune globulin.
- Have the skills to monitor patients for development and/or regression of coronary artery aneurysms.

SYSTEMS-BASED PRACTICE

- Establish long-term follow-up plans for patients and coordinate care with other disciplines as necessary (general pediatrics, infectious disease, and rheumatology).

PRACTICE-BASED LEARNING AND IMPROVEMENT

- Appropriately utilize current guidelines for the diagnosis and management of Kawasaki disease.
- Apply standard clinical criteria to establish the diagnosis of Kawasaki disease (10).

INTERPERSONAL COMMUNICATION AND SKILLS

- Communicate clearly with the family regarding the nature of the illness, clinical course, short- and long-term outcomes, and timing for follow-up and testing.

### 3.9. Evaluation and Management of Cardiac Manifestations of Genetic Syndromes

MEDICAL KNOWLEDGE

- Know the cardiac and cardiovascular manifestations of the common genetic syndromes (e.g., Marfan, Loeys-Dietz, Turner, Noonan, Williams and DiGeorge syndromes, and Trisomies 21, 13, 18).
- Know the genetic basis for congenital heart defects (11).
- Know the indications, limitations, and costs for prenatal and postnatal genetic testing (amniocentesis, chorionic villus sampling, karyotyping, fluorescence in situ hybridization (FISH), chromosomal microarray and whole-exome sequencing) and noninvasive imaging.
- Know the current studies and approaches to pharmacological prevention and treatment of cardiovascular sequelae of Marfan and Loeys-Dietz syndrome, including consideration of beta-adrenergic blockade and angiotensin receptor blockade (e.g., losartan).
- Know the indications for interventional catheter and/or surgical procedures for aortic aneurysm, coarctation, valvar, supravalvar, and branch pulmonary artery stenosis.

PATIENT CARE AND PROCEDURAL SKILLS

- Have the skills to formulate appropriate long-term follow-up and management plans, including transition to adult congenital heart disease programs.

SYSTEMS-BASED PRACTICE

- Obtain appropriate imaging studies in a cost-effective manner.

PRACTICE-BASED LEARNING AND IMPROVEMENT

- Adhere to clinical practice guidelines for genetic syndromes (12–14).

PROFESSIONALISM

- Collaborate with a multidisciplinary team to coordinate care of these patients.
- Protect privacy of genetic information.

INTERPERSONAL COMMUNICATION AND SKILLS

- Counsel family about cardiac conditions and implications for other medical problems.

### 3.10. Evaluation Tools

Duration of training and achievement of procedural volume requirements have played a foundational role in assessing competence of fellows to date. With the

**TABLE 1 Suggested Evaluation Tools for Competency Domains**

| | |
|---|---|
| **Medical Knowledge** | *Evaluation Tools: direct observation, conference participation and presentation, and in-training examination* |
| **Patient Care and Procedural Skills** | *Evaluation Tools: conference participation, direct observation, and procedure logs* |
| **Systems-Based Practice** | *Evaluation Tools: conference participation and presentation, direct observation, faculty evaluations, and 360 evaluations* |
| **Practice-Based Learning and Improvement** | *Evaluation Tools: meeting with mentors, review by Clinical Competency Committee, and reflection and self-assessment* |
| **Professionalism** | *Evaluation Tools: conference participation and presentation, direct observation, faculty evaluations, 360 evaluations, and reflection and self-assessment* |
| **Interpersonal and Communication Skills** | *Evaluation Tools: direct observation, faculty evaluations, and 360 evaluations* |

profession's movement toward a competency-based outcomes structure, it has become particularly important to identify evaluation tools that can demonstrate achievement of competencies. **Table 1** provides suggestions of evaluation tools, by competency domain, that can be used to assess whether fellows have obtained the competencies identified in this section.

## 4. EVALUATION AND DOCUMENTATION OF COMPETENCE

All training programs should include written goals and objectives for each pediatric cardiology rotation, with performance goals set according to the fellow's level of training. These will serve as the basis for formative feedback. A copy of these goals and objectives should be supplied and explained to the trainee at the onset of fellowship training and reviewed at the beginning of each rotation. Evaluation of fellows should be performed midway through, and at the completion of, each rotation; evaluations should be directed toward whether or not the fellow met those prespecified aims. The fellow evaluation should be performed by the pediatric cardiology training program director and/or the supervising physician for that rotation. The fellow evaluation should assess the fellow's performance in each of the 6 areas of core competencies, as appropriate for the level of training, and should be based on direct observation of the fellow. Evaluation of competency in preparation, performance, and interpretation of the results of a procedure should be given more consideration than a focus on the number of procedures performed. Evaluation of competency should be done in person with the trainee and documented in his or her fellowship record. If the trainee is not progressing as expected, remedial actions should be arranged and documented in accordance with institutional procedures. All fellows should maintain a log (preferably electronic) of all procedures performed.

## REFERENCES

**1.** Allen HD, Bricker JT, Freed MD, et al. ACCF/AHA/AAP recommendations for training in pediatric cardiology. Task force 1: general experiences and training. J Am Coll Cardiol. 2005;46:1382–4.

**2.** Jenkins KJ, Correa A, Feinstein JA, et al. Noninherited risk factors and congenital cardiovascular defects: current knowledge: a scientific statement from the American Heart Association Council on Cardiovascular Disease in the Young. Circulation. 2007;115:2995–3014.

**3.** Alvarez JA, Orav EJ, Wilkinson JD, et al. Competing risks for death and cardiac transplantation in children with dilated cardiomyopathy: results from the pediatric cardiomyopathy registry. Circulation. 2011;124:814–23.

**4.** Watkins H, Ashrafian H, Redwood C. Inherited cardiomyopathies. N Engl J Med. 2011;364:1643–56.

**5.** Gersh BJ, Maron BJ, Bonow RO, et al. 2011 ACCF/AHA guideline for the diagnosis and treatment of hypertrophic cardiomyopathy: a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines. J Am Coll Cardiol. 2011;58:e212–60.

**6.** Friedman KG, Kane DA, Rathod RH, et al. Management of pediatric chest pain using a standardized assessment and management plan. Pediatrics. 2011;128:239–45.

**7.** Benditt DG, Nguyen JT. Syncope: therapeutic approaches. J Am Coll Cardiol. 2009;53:1741–51.

**8.** Kapa S, Tester DJ, Salisbury BA, et al. Genetic testing for long-QT syndrome: distinguishing pathogenic mutations from benign variants. Circulation. 2009;120:1752–60.

**9.** Expert Panel on Integrated Guidelines for Cardiovascular Health and Risk Reduction in Children and Adolescents, National Heart, Lung, and Blood Institute. Expert panel on integrated guidelines for cardiovascular health and risk reduction in children and adolescents: summary report. Pediatrics. 2011;128 Suppl 5:S213–56.

**10.** Newburger JW, Takahashi M, Gerber MA, et al. Diagnosis, treatment, and long-term management of Kawasaki disease: a statement for health professionals from the Committee on Rheumatic Fever, Endocarditis and Kawasaki Disease, Council on Cardiovascular Disease in the Young, American Heart Association. Circulation. 2004;110:2747–71.

**11.** Pierpont ME, Basson CT, Benson DW Jr., et al. Genetic basis for congenital heart defects: current knowledge: a scientific statement from the American Heart Association Congenital Cardiac Defects Committee, Council on Cardiovascular Disease in the Young. Circulation. 2007;115:3015–38.

**12.** Bull MJ. Health supervision for children with Down syndrome. Pediatrics. 2011;128:393–406.

**13.** American Academy of Pediatrics: health care supervision for children with Williams syndrome. Pediatrics. 2001;107:1192–204.

**14.** Bondy CA. Care of girls and women with Turner syndrome: a guideline of the Turner Syndrome Study Group. J Clin Endocrinol Metab. 2007;92:10–25.

**KEY WORDS** SPCTPD/ACC/AAP/AHA Training Statement, ambulatory care, clinical competence, consultative care, fellowship training, pediatric cardiology

## APPENDIX 1. AUTHOR RELATIONSHIPS WITH INDUSTRY AND OTHER ENTITIES (RELEVANT)—TASK FORCE 1: PEDIATRIC CARDIOLOGY FELLOWSHIP TRAINING IN GENERAL CARDIOLOGY

| Committee Member | Employment | Consultant | Speakers Bureau | Ownership/ Partnership/ Principal | Personal Research | Institutional/ Organizational or Other Financial Benefit | Expert Witness |
|---|---|---|---|---|---|---|---|
| Alan B. Lewis *(Co-Chair)* | Children's Hospital of Los Angeles—Director, Cardiology Fellowship Program; University of Southern California—Professor of Pediatrics | None | None | None | None | None | None |
| Gerard R. Martin *(Co-Chair)* | Children's National Health System—Senior Vice President; Center for Heart, Lung and Kidney Disease—C. Richard Beyda Distinguished Professor of Cardiology and Medical Director, Global Services | None | None | None | None | None | None |
| Peter J. Bartz | Children's Hospital of Wisconsin, Medical College of Wisconsin—Associate Professor of Pediatrics—Cardiology & Medicine—Cardiovascular Diseases | None | None | None | None | None | None |
| Peter S. Fischbach | Emory University—Associate Professor; Children's Healthcare of Atlanta | None | None | None | None | None | None |
| David R. Fulton | Boston Children's Hospital—Associate Cardiologist-in-Chief for Administration; Chief, Cardiology Outpatient Services, Department of Cardiology; and Associate Professor of Pediatrics | None | None | None | None | None | None |
| G. Paul Matherne | University of Virginia Children's Hospital—Vice Chair for Clinical Affairs and Associate Chief Medical Officer | None | None | None | None | None | None |
| Benjamin Reinking | University of Iowa Children's Hospital, Stead Family Department of Pediatrics, Division of Pediatric Cardiology—Director, Clinical Cardiology and Director, Pediatric Cardiology Fellowship Program | None | None | None | None | None | None |
| Robert L. Spicer | University of Nebraska and Creighton University Schools of Medicine—Professor of Pediatrics; Children's Hospital & Medical Center—Chief of Cardiology | None | None | None | None | None | None |

For the purpose of developing a general cardiology training statement, the American College of Cardiology (ACC) determined that no relationships with industry (RWI) or other entities were relevant. This table reflects authors' employment and reporting categories. To ensure complete transparency, authors' comprehensive healthcare-related disclosure information—including RWI not pertinent to this document—is available in an online data supplement. Please refer to http://www.acc.org/guidelines/about-guidelines-and-clinical-documents/relationships-with-industry-policy for definitions of disclosure categories, relevance, or additional information about the ACC Disclosure Policy for Writing Committees.

## APPENDIX 2. PEER REVIEWER RELATIONSHIPS WITH INDUSTRY AND OTHER ENTITIES (RELEVANT)—TASK FORCE 1: PEDIATRIC CARDIOLOGY FELLOWSHIP TRAINING IN GENERAL CARDIOLOGY

| Name | Employment | Representation | Consultant | Speakers Bureau | Ownership/ Partnership/ Principal | Personal Research | Institutional/ Organizational or Other Financial Benefit | Expert Witness |
|---|---|---|---|---|---|---|---|---|
| Antonio Cabrera | Texas Children's Hospital—Pediatric Cardiology | AAP | None | None | None | None | None | None |
| Timothy Feltes | Nationwide Children's Hospital—Chief, Pediatric Cardiology and Co-Director of the Heart Center | ACC ACPC Council | None | None | None | None | None | None |
| Regina Lantin-Hermoso | Texas Children's Hospital | ACC ACPC Council | None | None | None | None | None | None |
| Sara Pasquali | University of Michigan Health System—Associate Professor of Pediatrics | AHA | None | None | None | None | None | None |
| Swee Chye Quek | National University of Singapore, Department of Pediatrics | ACC ACPC Council | None | None | None | None | None | None |
| Carole Warnes | Mayo Clinic—Professor, Medicine | ACC BOT | None | None | None | None | None | None |
| Eric S. Williams | Indiana University School of Medicine—Professor (Cardiology) and Associate Dean; Indiana University Health—Cardiology Service Line Leader | ACC CMC Lead Reviewer | None | None | None | None | None | None |

For the purpose of developing a general cardiology training statement, the ACC determined that no relationships with industry or other entities were relevant. This table reflects peer reviewers' employment, representation in the review process, as well as reporting categories. Names are listed in alphabetical order within each category of review. Please refer to http://www.acc.org/guidelines/about-guidelines-and-clinical-documents/relationships-with-industry-policy for definitions of disclosure categories, relevance, or additional information about the ACC Disclosure Policy for Writing Committees.

AAP indicates American Academy of Pediatrics; ACC, American College of Cardiology; ACPC, Adult Congenital and Pediatric Cardiology; AHA, American Heart Association; BOT, Board of Trustees; and CMC, Competency Management Committee.

JOURNAL OF THE AMERICAN COLLEGE OF CARDIOLOGY
© 2015 BY THE SOCIETY OF PEDIATRIC CARDIOLOGY TRAINING PROGRAM DIRECTORS, AMERICAN COLLEGE OF CARDIOLOGY FOUNDATION, AMERICAN ACADEMY OF PEDIATRICS, AND THE AMERICAN HEART ASSOCIATION, INC.
PUBLISHED BY ELSEVIER INC.

VOL. 66, NO. 6, 2015
ISSN 0735-1097/$36.00
http://dx.doi.org/10.1016/j.jacc.2015.03.010

TRAINING STATEMENT

# Task Force 2: Pediatric Cardiology Fellowship Training in Noninvasive Cardiac Imaging

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

Shubhika Srivastava, MBBS, FAAP, FACC, FASE, *Co-Chair*
Beth F. Printz, MD, PhD, FAAP, FASE, *Co-Chair*
Tal Geva, MD, FACC
Girish S. Shirali, MBBS, FACC, FASE
Paul M. Weinberg, MD
Pierre C. Wong, MD
Peter Lang, MD, FAAP, FACC

## 1. INTRODUCTION

### 1.1. Document Development Process

The Society of Pediatric Cardiology Training Program Directors (SPCTPD) board assembled a steering committee that nominated 2 chairs, 1 SPCTPD steering committee member, and 4 additional experts from a wide range of program sizes, geographic regions, and subspecialty focuses. Representatives from the American College of Cardiology (ACC), American Academy of Pediatrics (AAP), and American Heart Association (AHA) participated. The steering committee member was added to provide perspective to each task force as a "nonexpert" in that field. Relationships with industry and other entities were not deemed relevant to the creation of a general cardiology training statement; however, employment and affiliation information for authors and peer reviewers are provided in Appendixes 1 and 2, respectively, along with disclosure reporting categories. Comprehensive disclosure information for all authors, including relationships with industry and other entities, is available as an online supplement to this document.

The writing committee developed the document, approved it for review by individuals selected by the participating organizations (Appendix 2), and addressed their comments. The final document was approved by the SPCTPD, AAP, and AHA, as well as endorsed by the Society of Pediatric Echocardiography in February 2015. It was endorsed by the American Society of Echocardiography and approved by the ACC in March 2015. This document is considered current until the SPCTPD revises or withdraws it.

### 1.2. Background and Scope

For over 25 years, noninvasive cardiac imaging has been the mainstay of anatomic and physiological assessment in pediatric cardiology and congenital heart disease. An ACC/AAP/AHA combined task force published pediatric noninvasive cardiac imaging training guidelines in 2005, including guidelines for training in transthoracic (TTE), transesophageal (TEE), and fetal echocardiography, as well as in cardiac magnetic resonance imaging (MRI) (1). These guidelines, which were also endorsed by the American Society of Echocardiography and the Society of Pediatric Echocardiography, established standard goals, training methods, and expected levels of expertise for core and advanced levels of pediatric cardiology fellowship training.

The American College of Cardiology requests that this document be cited as follows: Srivastava S, Printz BF, Geva T, Shirali GS, Weinberg PM, Wong PC, Lang P. Task force 2: pediatric cardiology fellowship training in noninvasive cardiac imaging. J Am Coll Cardiol 2015;66:687–98.

This article is copublished in *Circulation* and reprinted in the *Journal of the American Society of Echocardiography*.

With continued advancement in the field of noninvasive imaging since the publication of these guidelines, the scope of training, expected level of expertise, and knowledge of existing information technology infrastructure supporting these imaging modalities have evolved. Use of imaging techniques such as cardiac MRI, 3-dimensional (3D) echocardiography, and new applications such as strain imaging have become more commonplace in everyday practice. Additionally, the noninvasive imaging work environment has incorporated methods to evaluate and maintain quality and to establish performance standards (2). There has also been a recent initiative to develop tools for assessment of quality and accuracy in performing and reporting pediatric echocardiograms.

The revised training recommendations describe program resources and the environment that are required for training pediatric cardiology fellows, together with a competency-based system promulgated by the American College of Graduate Medical Education (ACGME), to implement specific goals and objectives for training pediatric cardiology fellows. This system categorizes competencies into 6 core competency domains: Medical Knowledge, Patient Care and Procedural Skills, Systems-Based Practice, Practice-Based Learning and Improvement, Professionalism, and Interpersonal and Communication Skills, along with identification of suggested evaluation tools for each domain. Competencies unique to noninvasive imaging, along with suggested evaluation tools, are listed in Appendix 3 (see the "2015 SPCTPD/ACC/AAP/AHA Training Guidelines for Pediatric Cardiology Fellowship Programs [Revision of the 2005 Training Guidelines for Pediatric Cardiology Fellowship Programs]: Introduction" for additional competencies and evaluation tools that apply to all Task Force reports).

Echocardiography herein refers to all ultrasound-based imaging techniques used to assess cardiac anatomy and function. This is inclusive of 2-, 3-, and 4-dimensional imaging of the heart and related structures, functional assessment ranging from M-mode assessment, 2- and 3-dimensional, and speckle tracking to assess global and regional deformation, color Doppler imaging, as well as pulsed and continuous-wave spectral Doppler imaging for flow, hemodynamics, and tissue motion. Cardiac MRI refers to anatomic and functional cardiovascular MRI for assessment of congenital heart disease (CHD) in children and adults, as well as for assessment of acquired forms of heart disease in children.

### 1.3. Levels of Expertise—Core and Advanced

Innovations in the field of echocardiography have led to noninvasive diagnosis of complex CHD, frequently precluding the need for diagnostic catheterization. Therefore, physicians performing these procedures should be skilled in all aspects of echocardiography. Those choosing noninvasive imaging for a career should be trained in advanced transthoracic echocardiography, as well as some combination of TEE, fetal echocardiography, and/or cardiac MRI.

Two levels of fellowship training are discussed in this statement: core and advanced. Guidelines for the core level of training should be considered as minimum, mandated reference standards for a fellow to achieve competency in noninvasive cardiac imaging during standard 3-year pediatric cardiology fellowship training. The training should allow for independent and accurate use of TTE imaging to diagnose simple CHD, as well as acquired pediatric heart disease. A thorough education in TTE, as well as exposure to TEE, fetal echocardiography, and cardiac MRI is essential for core pediatric cardiology training. Education in TEE, fetal echocardiography, and cardiac MRI during the core training period should allow for familiarity with techniques, indications, and limitations. Echocardiography skills for the diagnosis of more complex congenital heart disease, as well as expertise in other advanced imaging modalities inclusive of fetal echocardiography, TEE, MRI and their applications, will be considered as requirements for advanced noninvasive imaging training, as described in the following text. It is anticipated that fellows may, but are not required to, obtain levels of competence above the minimum core requirements in these advanced imaging skills (including diagnosis of complex congenital heart disease, fetal echocardiography, TEE, and/or cardiac MRI) during their core noninvasive imaging fellowship experience.

## 2. PROGRAM RESOURCES AND ENVIRONMENT

### 2.1. Echocardiography

The echocardiographic facility (laboratory) required for core pediatric cardiology fellowship training must encompass inpatient and outpatient services. The training facility should include neonatal, pediatric, and/or cardiac intensive care units, an invasive/interventional catheterization laboratory, and a cardiac surgical program. The echocardiography laboratory should perform an adequate volume of studies with expert faculty dedicated to echocardiography, so as to provide trainees with teaching and exposure to both normal and abnormal examinations in patients across a wide age range, from fetal patients to the growing population of adults with CHD. The pediatric echocardiography laboratory should be under the supervision of a designated pediatric cardiologist who has primary responsibility for supervision of the laboratory. The equipment and inventory should be maintained to ensure high-quality performance and to comply with regulations and guidelines for patient safety for sedation. Trainees should have access to

patients with a broad spectrum of congenital and acquired cardiac pathologies. A recent survey of pediatric cardiology fellowship program directors (conducted by the Noninvasive Task Force composed of the authors of this document) demonstrated that this framework for training exists in the echocardiography laboratories of most of the current training programs (Appendix 4).

### 2.2. Cardiac MRI

Training in pediatric cardiac MRI should occur within a pediatric cardiology fellowship program and/or a radiology training program accredited by the ACGME and staffed by qualified physicians with dedicated expertise in pediatric or congenital cardiac MRI. The MRI laboratory should serve a hospital or hospitals with both inpatient and outpatient services. The training facility should include neonatal and pediatric/cardiac intensive care units, an invasive/interventional catheterization laboratory, and a cardiac surgical program. The MRI laboratory should perform an adequate volume of cardiac studies so as to provide trainees with exposure to both normal and abnormal examinations in patients across a wide age range, from neonatal patients to the growing population of adults with CHD. The MRI laboratory should be supervised by a pediatric cardiologist and/or radiologist with special expertise in pediatric and congenital cardiac MRI. The equipment and inventory should be maintained to ensure high-quality performance and to comply with regulations and guidelines for patient safety with sedation. Core and advanced fellowship trainees should have access to pediatric patients with a broad spectrum of congenital and acquired cardiac pathologies, as well as to adults with various forms of CHD.

## 3. CORE TRAINING: GOALS AND METHODS

### 3.1. Echocardiography

During their core fellowship training experience, all pediatric cardiology fellows should be able to achieve technical competence in performing a TTE and should acquire the knowledge base to interpret and report the studies. It is important to have an environment that supports this training, ideally in an accredited echocardiography laboratory. The echocardiography laboratory should have sufficient volume to expose clinical pediatric cardiology fellows to a full range of cardiac pathologies and sufficient attending staff to supervise them and teach the necessary skills. To allow adequate supervision of fellows as they are trained in echocardiography, the following considerations with respect to the infrastructure of the training environment should be ensured:

- Adequate ratio of clinical volume to the number of sonographers to ensure that each fellow will be able to perform and interpret the minimum number of echocardiograms required for core fellowship training.
- Adequate ratio of clinical volume to the number of attending staff to ensure that each fellow will receive adequate instruction.
- Sufficient time allocation per study to allow for the training experience.
- Standard protocol implementation for image acquisition and reporting of studies (as discussed in the following text).
- System of real-time fellow supervision, instruction, and evaluation by dedicated pediatric/congenital echocardiography staff.
- Quality assessment and improvement processes, including tools to detect and review diagnostic errors or discrepancies and to correlate findings with other imaging modalities.
- Comprehensive teaching program that includes didactic conferences, case review sessions, and so on.
- Mentored research opportunities for fellowship trainees.

Standard echocardiographic imaging and measurement protocols are essential in a teaching pediatric echocardiography laboratory to maintain quality and uniformity of complete TTE, TEE, and fetal examinations. Imaging protocol guidelines for performance of pediatric TTE, TEE, and fetal echocardiograms have been published by the American Society of Echocardiography (3–8). Besides imaging protocols, the echocardiography laboratory should have in place a comprehensive normative dataset or Z-score database encompassing the full range of body sizes and ages encountered in a pediatric/congenital laboratory against which to compare measurements performed in the laboratory; this can be accomplished through 1 of several currently available pediatric echocardiography normative databases.

#### 3.1.1. Transthoracic Echocardiography

During the core noninvasive imaging experience, the trainee should perform and interpret a sufficient number of echocardiograms to attain proficiency with the following parameters:

- To allow the certifying faculty to render a *credible assessment of a fellow's level of competency*, the fellow trainee should perform and interpret a minimum of 150 echocardiograms and review and interpret an additional 100 echocardiograms during the 3 years (see Appendix 5). These should be considered minimum numbers to allow for *assessment* and not as minimum numbers for the fellow to be considered *competent* in TTE, which may be greater.
- The trainee should be exposed to a wide range of diagnoses, including presurgical and postsurgical

evaluation of simple and complex congenital and acquired heart diseases that span the age spectrum from neonates to adults.
- The trainee should be familiar with the institutional sedation and monitoring policies for echocardiograms in both the inpatient and outpatient settings.
- There should be a didactic teaching schedule that incorporates such topics as basic principles of ultrasound, the segmental approach to diagnosis of CHD, and the use of echocardiography for quantitative assessment and hemodynamic evaluation.
- There should be direct demonstration of echocardiographic cases and 1-on-1 supervision in addition to didactic teaching.
- The trainee should have access to echocardiography-pathology correlates, either through direct exposure to heart specimens, at conferences, or through electronic media.
- Attending cardiologists and senior sonographers that teach imaging skills to fellows should be aware of the training goals. These instructors should discuss the goals with the trainee at the beginning of the rotation, and they should provide ongoing evaluation.
- There should be conferences and discussions detailing anatomic and surgical correlates.
- The utility and limitations of echocardiography and other imaging modalities such as cardiac MRI, cardiac computed tomography (CT), and cardiac catheterization should be taught.
- The trainee should both be aware of and be exposed to the process for continued quality improvement and echocardiographic laboratory accreditation.
- Although the ability to perform and/or interpret fetal and TEE studies is not a core training requirement, there should be exposure to these modalities during core fellowship training for all trainees.
- Core fellows should be involved in the review process and didactic lectures regarding fetal and TEE studies, including indications for these examinations and their limitations.

#### 3.1.2. Transesophageal Echocardiography

Fellows completing 3 years of core cardiology training are not expected to perform or interpret TEE. However, those with an interest in pursuing a career in noninvasive imaging may wish to obtain experience in TEE during the latter part of their core training. Moreover, during the course of their 3-year training, fellows will often encounter situations in which they are required to order, review, and/or present TEE studies. Hence, they should be familiar with the general aspects of the procedure, including its advantages and limitations (5), as well as the individual TEE views and how they are utilized to evaluate congenital and acquired heart disease.

Recommended goals for core fellowship training in TEE, therefore, include knowledge of the following:

- Indications and use of TEE in the operating room, interventional (cardiac catheterization) laboratory, intensive care unit, and outpatient settings.
- Strengths and limitations of TEE.
- Contraindications and potential complications of TEE.
- Familiarity with the TEE views obtainable from the major esophageal/gastric positions; these include the midesophageal, upper esophageal, transgastric, and deep transgastric, as well as supplementary views such as of the descending aorta (7).

For the trainee to satisfy these guidelines, the program must incorporate these topics into the general curriculum. This could be achieved in multiple ways, including didactic lectures, case discussions between cardiology fellows and pediatric cardiologists (or other qualified physicians) with expertise in pediatric/congenital heart TEE, video and "hands-on" demonstrations, and/or multidisciplinary meetings such as combined cardiac surgery and cardiology conferences.

#### 3.1.3. Fetal Echocardiography

Fellows completing 3 years in general cardiology training are not required to perform or interpret fetal echocardiograms, but all fellows are required to be knowledgeable about the subject (8–11). As with TEE, some trainees may wish to attain a higher level of competency in performing and interpreting fetal echocardiography during core fellowship.

The following represents recommended minimum knowledge for core training in fetal echocardiography.

- Indications for, and limitations of, fetal echocardiography.
- Gestational age at which to refer for a fetal echocardiogram.
- Normal physiology of fetal and transitional circulation.
- Alterations in fetal circulation associated with CHD that impact outcome.
- Fetal arrhythmia evaluation, management, outcomes, and utility of fetal echocardiographic monitoring.
- Extracardiac anomalies in the fetus that impact prenatal and perinatal outcome.
- Existing innovations in perinatal management.

For the trainee to satisfy these guidelines, there must be a provision in the program to incorporate these topics into the general curriculum. This could be achieved in multiple ways, including didactic lectures, video and "hands-on" demonstrations, journal club, and/or multidisciplinary meetings such as combined perinatal and cardiology conferences.

### 3.2. Cardiac MRI

Guidelines for training in pediatric cardiac MRI were published as part of the 2005 pediatric cardiology noninvasive cardiac imaging guidelines document (1), from which these revised training guidelines have been adapted. Guidelines to achieve clinical competence in cardiac MRI and CT as part of *adult* cardiology fellowship training have also been published (12–14). There is significant variation amongst institutions with respect to availability of pediatric cardiac MRI and in the expertise of pediatric cardiologists, adult cardiologists, and radiologists in performing pediatric/congenital cardiac MRI. Thus, the training guidelines described in the following text are suggested requirements. Similarly, institutions may also choose to include knowledge of cardiovascular CT indications, advantages, and disadvantages for imaging in children and adults with CHD as part of their core pediatric cardiology fellowship curriculum, and may choose to include some level of competency in interpretation of cardiovascular CT as part of advanced noninvasive cardiac imaging training, depending on the level of institutional expertise and equipment availability.

Fellows completing 3 years of general pediatric cardiology training are not required to perform or interpret cardiac MRIs. However, the graduating pediatric cardiology fellow is required to be knowledgeable about cardiac MRI. He or she would be expected to refer patients for cardiac MRI when appropriate, and should be able to view cardiac MRI images and incorporate diagnostic cardiac MRI reports as components of a patient's clinical evaluation. With this in mind, the following are guidelines for core training in cardiac MRI:

- Familiarity with basic principles used to generate MRI images.
- Awareness of current indications and contraindications for cardiac MRI
  - In patients with CHD, including children and adults,
  - In children with acquired heart disease, such as for assessment of ventricular volumes, mass, and/or function.
- Ability to read basic cardiac MRI acquired in infants, children, and young adults with either structurally normal or abnormal hearts.

For a pediatric cardiology fellowship trainee to satisfy these core cardiac MRI training guidelines, there must be provisions within the core fellowship training program that incorporate these topics into the general curriculum. This could be achieved in several ways, including: 1) case discussions with direct interaction between the core pediatric cardiology fellow and pediatric cardiologists or cardiac radiologists who have special expertise in cardiac MRI, including advanced cardiac MRI fellowship trainees, during the acquisition and interpretation of cardiac MRIs; 2) didactic lectures, videos, continuing medical education conferences, and "hands-on" demonstrations; and 3) multidisciplinary meetings, such as combined cardiology, radiology, and/or pathology conferences.

## 4. ADVANCED TRAINING: GOALS AND METHODS

The goal for advanced training in cardiac imaging is to train fellows to be competent to assume positions as independent noninvasive imaging physicians. Advanced noninvasive cardiac imaging training should include research, teaching, and education components specific to imaging, in addition to advanced clinical expertise in imaging. As with core fellowship training, numerical benchmarks for advanced fellowship trainees are less important than competency-based benchmarks; procedural numbers listed in this section are considered as guides to establish sufficiently broad-based criteria for faculty to make educated, nonbiased assessments of fellowship competency in these advanced imaging modalities.

Advanced training may include all or any combination of TTE, TEE, fetal echocardiography, and cardiac MRI. To achieve competence in advanced pediatric and congenital cardiac noninvasive imaging, an additional 6 to 12 months of training is required beyond the core 3-year training period. The duration of training would depend upon the goal of training, requiring at least 6 months to achieve advanced competency in echocardiography (inclusive of TTE, TEE, and fetal echocardiography) or cardiac MRI alone, and may extend over 12 months to achieve "advanced" competence in noninvasive imaging for both echocardiography and cardiac MRI. Because the ACGME does not currently recognize this advanced training, the suggested training guidelines are not as standardized as are those for core imaging training. Advanced imaging training may vary based on the particular training program and on the individual trainee, because of: 1) variability among institutions with regard to structure, method, and focus of training modality (e.g., TTE, TEE, fetal echocardiography, cardiac MRI); and 2) variability in goal competency levels to be achieved by the particular advanced fellow for each of these modalities. For example, an advanced imaging fellow might focus his/her training more on perfecting fetal imaging skills rather than on cardiac MRI. However, the following are recommended general goals for advanced echocardiographic training; specific guidelines and objectives for fetal echocardiography, TEE, and cardiac MRI are listed separately. Although advanced training guidelines for each of the listed imaging modalities will be discussed individually, the following methods are common to all:

- Teaching and supervising junior fellows and sonographers.

- Active involvement in research and teaching: a scholarly activity project should be defined at the onset of advanced training and should be monitored closely, culminating with a presentation at a national meeting and submission of a manuscript for publication in a peer-reviewed journal.
- Increasing level of independence in performing and interpreting studies, clinical decision making, and in the advanced fellow's interaction with surgeons, interventionalists, and referring physicians.

The advanced imaging fellow should understand the process of running an echocardiographic/noninvasive imaging laboratory, as well as its individual components such as staffing, scheduling, reporting, quality assurance procedures, and billing.

### 4.1. Echocardiography

- Independently perform and interpret TTEs in patients of all ages and diagnostic complexity. *It is expected that mastering diagnostic imaging of complex CHD may require additional years of experience and supervision following completion of advanced training.*
- Independently utilize echocardiographic data to guide clinical decisions in children and young adults with congenital and acquired heart disease.
- Know quantitative methods of systolic and diastolic ventricular function assessment.
- Know how to interpret and report regional ventricular function.
- Observe and be familiar with applications and limitations of 3-dimensional imaging and myocardial deformation assessment.
- Be able to supervise sonographers and junior fellows and help them acquire core skills.
- Develop and/or participate in noninvasive imaging-related research, with a goal of project completion as evidenced by presentation at a national meeting and manuscript publication.
- Be familiar with echocardiographic imaging implications and uses of telemedicine.

#### 4.1.1. Transthoracic Echocardiography

- Perform and interpret at least 100 TTE examinations, and review and interpret at least 100 TTE examinations performed by others in patients with more complex anatomy, over a wide age range inclusive of infants and adults. Such examinations should include repaired, palliated, and unrepaired CHD, as well as pediatric forms of acquired heart disease.
- Be proficient in advanced quantitative and hemodynamic assessment using 2- and 3-dimensional and myocardial deformation imaging techniques.

#### 4.1.2. Transesophageal Echocardiography

The goal of advanced training is to enable the trainee to achieve competence in the performance and interpretation of TEE for the evaluation of congenital and acquired heart disease in pediatric patients. In addition to the core knowledge of TEE outlined in the previous text, the following guidelines are recommended for advanced training:

- The trainee should perform and interpret at least 50 studies in pediatric and adult congenital patients. Such patients should comprise a varied spectrum of patient ages and sizes, from neonates to young adults. The studies should be performed under the direct supervision of a dedicated pediatric cardiologist-echocardiographer or other qualified physician with specialized expertise in pediatric/congenital heart TEE (5).
- Trainees should understand oropharyngeal anatomy and the technique of esophageal intubation, as well as the potential risks of TEE and contraindications for the procedure.
- Performing a competent TEE study requires safe and skillful manipulation of the transducer; an understanding and interpretation of the information obtained; and accurate, comprehensive recording of the entire study. Trainees should be expected to acquire the skills necessary to perform a complete diagnostic evaluation of the heart, utilizing the various TEE probe manipulations and esophageal positions (5,7). Obtaining a complete study necessitates the use of the methods common to all forms of echocardiography—2-dimensional imaging, color flow and spectral Doppler, and (when appropriate) M-mode imaging. In the intraoperative setting, the trainee should recognize the changing hemodynamic conditions following surgery and their potential impact upon the echocardiographic findings.
- Trainees should be able to perform a diagnostic TEE study in patients with all forms of pediatric heart disease. This includes patients with complex CHD and cardiac malpositions, such as mesocardia and dextrocardia, in which evaluation of situs and careful segmental evaluation are paramount. Trainees should also be able to evaluate acquired forms of heart disease that might require TEE such as endocarditis and intracardiac thrombus.
- The most common environment for the performance of pediatric TEE is the intraoperative setting, in which both preoperative and postoperative studies are generally obtained. However, the training experience should not be limited to this venue; training should also be conducted in other locations for TEE such as the cardiac catheterization laboratory, intensive care unit, and outpatient setting.

- Trainees should understand the indications for the TEE procedure and the requisite information that must be obtained for any given patient, including informed consent. This includes prior review of the patient's history and previous imaging studies (when available). Given the time constraints often accompanying a TEE study, particularly in the intraoperative setting, the trainee will need to prioritize the study such that the most relevant information is acquired first, and supplementary information obtained afterward (time permitting).
- During surgical or cardiac catheterization procedures, it is essential that the echocardiographer communicates important TEE findings in a timely and clear manner to the surgeon or interventionalist, as well as to other members of the team such as the anesthesiologist. Pertinent positive and negative information must be articulated quickly, lucidly, and accurately. It is important for the trainee to understand the importance of team communication and to demonstrate the ability to do so.

#### 4.1.3. Fetal Echocardiography

The goal of advanced fetal echocardiography training is to achieve competence with variable degree of supervision in the diagnosis, counseling, and perinatal management of the fetal diagnosis of congenital heart defects, arrhythmia, heart failure, and derangements in fetal physiology with cardiac and extracardiac fetal malformations (8–11). Recognizing that the percentage of fetal echocardiograms performed on those with CHD will vary from center to center, it is difficult to define a specific number of studies required to obtain competence that is generalizable to all programs. As a guideline, the advanced fetal echocardiography trainee should:

- Be involved in performance and interpretation and parental counseling of at least 50 fetal echocardiograms and additionally review and interpret another 50. Of these 100, at least 50 echocardiograms should have some form of CHD and/or abnormality of fetal circulation. This should ensure acquisition of knowledge and the technical skills required for assessment and recognition of normal and abnormal fetal cardiac anatomy, function, and physiology. The advanced trainees should have exposure to normal screening examinations and fetuses with a wide range of simple and complex heart defects, fetal arrhythmias, and derangements in fetal physiology.
- Be involved in fetal counseling as it pertains to diagnosis, associated syndromes, implications, and outcomes.
- Have the knowledge and skills needed to assess hemodynamic derangements and plan postnatal management of extracardiac conditions and in those with multiple gestations that can alter fetal hemodynamics.
- Actively participate in a multidisciplinary team approach involved in perinatal management of fetal CHD, arrhythmia, or heart failure.
- Be aware of the utility, indications, and safety of other imaging modalities such as MRI in the management of a fetus with CHD, arrhythmia, and/or extracardiac defects.

### 4.2. Cardiac MRI

The goal of advanced cardiac MRI training is to achieve competence to perform and independently interpret cardiac MRI examinations in children and in adults with CHD. There is currently discussion within the Society of Cardiac Magnetic Resonance regarding development of specific advanced training credentialing guidelines for both pediatric and adult cardiac MRI. Until such specific guidelines have been approved, it is anticipated that advanced training in pediatric cardiac and congenital MRI should include at minimum an additional 3 to 6 months of training beyond the standard core pediatric cardiology training experience, either as part of an advanced noninvasive cardiac imaging fellowship that also includes TTE, fetal, and TEE imaging, or as a separate advanced cardiac MRI training program.

To achieve this goal, the advanced cardiac MRI trainee should:

- Interpret at least 100 cardiac MRI examinations, including assessment of cardiac anatomy, function, and physiology; for at least 50 cardiac MRI examinations, the advanced cardiac MRI trainee should be directly involved in the acquisition and interpretation of the study. The trainee should have adequate exposure to a broad range of simple and complex heart defects in children and adults with CHD, as well as exposure to the spectrum of acquired heart disease in children.
- Develop an understanding of MRI physics, instrumentation, nomenclature, and MRI safety.
- Participate in the training of MRI technologists and core cardiology trainees in cardiac MRI techniques, including image acquisition and interpretation.
- Participate in basic and/or clinical research project(s) in cardiac MRI, including the presentation of original data at 1 or more scientific meetings, together with original manuscript preparation.
- Participate in quality improvement initiatives within the cardiac MRI laboratory.

## 5. EVALUATION AND DOCUMENTATION OF COMPETENCE

All training programs should include written goals and objectives for each imaging rotation with performance goals set according to the fellow's level of training. These will serve as the basis for feedback. A copy of these goals and objectives should be supplied and explained to the trainee at the onset of fellowship training and reviewed at the beginning of each rotation. Evaluation of fellows should be performed midway through, and at the completion of, each rotation; evaluations should be directed toward whether the fellow met those prespecified aims. The fellow evaluation should be performed by the echocardiographer/cardiac MRI laboratory director and/or senior echocardiographer/cardiac MRI physician chosen as director of noninvasive imaging training. The fellow evaluation should assess the fellow's performance in each of the 6 areas of core competencies, as appropriate for the level of training, and should be based on direct observation of the fellow. Evaluation of competency in preparation, performance, and interpretation of the results of a procedure should be given more consideration than a focus on the number of procedures performed. Evaluation of competency should be done in person with the trainee and documented in his or her fellowship record. If the trainee is not progressing as expected, remedial actions should be arranged and documented in accordance with institutional procedures. All fellows should maintain a log (preferably electronic) of all procedures performed.

## REFERENCES

**1.** Sanders SP, Colan SD, Cordes TM, et al. ACCF/AHA/AAP recommendations for training in pediatric cardiology. Task force 2: pediatric training guidelines for noninvasive cardiac imaging. J Am Coll Cardiol. 2005;46:1384–8.

**2.** Benavidez OJ, Gauvreau K, Jenkins KJ, et al. Diagnostic errors in pediatric echocardiography: development of taxonomy and identification of risk factors. Circulation. 2008;117:2995–3001.

**3.** Campbell RM, Douglas PS, Eidem BW, et al. ACC/AAP/AHA/ASE/HRS/SCAI/SCCT/SCMR/SOPE 2014 appropriate use criteria for initial transthoracic echocardiography in outpatient pediatric cardiology: a report of the American College of Cardiology Appropriate Use Criteria Task Force, American Academy of Pediatrics, American Heart Association, American Society of Echocardiography, Heart Rhythm Society, Society for Cardiovascular Angiography and Interventions, Society of Cardiovascular Computed Tomography, Society for Cardiovascular Magnetic Resonance, and Society of Pediatric Echocardiography. J Am Coll Cardiol. 2014;64:2039–60.

**4.** Lai WW, Geva T, Shirali GS, et al. Guidelines and standards for performance of a pediatric echocardiogram: a report from the Task Force of the Pediatric Council of the American Society of Echocardiography. J Am Soc Echocardiogr. 2006;19:1413–30.

**5.** Ayres NA, Miller-Hance W, Fyfe DA, et al. Indications and guidelines for performance of transesophageal echocardiography in the patient with pediatric acquired or congenital heart disease: report from the Task Force of the Pediatric Council of the American Society of Echocardiography. J Am Soc Echocardiogr. 2005;18:91–8.

**6.** Lopez L, Colan SD, Frommelt PC, et al. Recommendations for quantification methods during the performance of a pediatric echocardiogram: a report from the Pediatric Measurements Writing Group of the American Society of Echocardiography Pediatric and Congenital Heart Disease Council. J Am Soc Echocardiogr. 2010;23:465–95.

**7.** Shanewise JS, Cheung AT, Aronson S, et al. ASE/SCA guidelines for performing a comprehensive intraoperative multiplane transesophageal echocardiography examination: recommendations of the American Society of Echocardiography Council for Intraoperative Echocardiography and the Society of Cardiovascular Anesthesiologists Task Force for Certification in Perioperative Transesophageal Echocardiography. J Am Soc Echocardiogr. 1999;12:884–900.

**8.** Rychik J, Ayres N, Cuneo B, et al. American Society of Echocardiography guidelines and standards for performance of the fetal echocardiogram. J Am Soc Echocardiogr. 2004;17:803–10.

**9.** AIUM practice guideline for the performance of fetal echocardiography. J Ultrasound Med. 2011;30:127–36.

**10.** Lee W, Allan L, Carvalho JS, et al. ISUOG consensus statement: what constitutes a fetal echocardiogram? Ultrasound Obstet Gynecol. 2008;32:239–42.

**11.** Allan L, Dangel J, Fesslova V, et al. Recommendations for the practice of fetal cardiology in Europe. Cardiol Young. 2004;14:109–14.

**12.** Thomas JD, Zoghbi WA, Beller GA, et al. ACCF 2008 training statement on multimodality noninvasive cardiovascular imaging: a report of the American College of Cardiology Foundation/American Heart Association/American College of Physicians Task Force on Clinical Competence and Training. Developed in collaboration with the American Society of Echocardiography, the American Society of Nuclear Cardiology, the Society of Cardiovascular Computed Tomography, the Society for Cardiovascular Magnetic Resonance, and the Society for Vascular Medicine. J Am Coll Cardiol. 2009;53:125–46.

**13.** Budoff MJ, Cohen MC, Garcia MJ, et al. ACCF/AHA clinical competence statement on cardiac imaging with computed tomography and magnetic resonance: a report of the American College of Cardiology Foundation/American Heart Association/American College of Physicians Task Force on Clinical Competence and Training. Developed in collaboration with the American Society of Echocardiography, American Society of Nuclear Cardiology, Society of Atherosclerosis Imaging, and the Society for Cardiovascular Angiography and Interventions. J Am Coll Cardiol. 2005;46:383–402.

**14.** Beller GA, Bonow RO, Fuster V. ACCF 2008 recommendations for training in adult cardiovascular medicine core cardiology training (COCATS 3) (revision of the 2002 COCATS Training Statement). J Am Coll Cardiol. 2008;51:335–8.

**KEY WORDS** SPCTPD/ACC/AAP/AHA Training Statement, cardiac magnetic resonance imaging, clinical competence, echocardiography, fellowship training, fetal echocardiography, pediatric cardiology, transesophageal echocardiography, transthoracic echocardiography

## APPENDIX 1. AUTHOR RELATIONSHIPS WITH INDUSTRY AND OTHER ENTITIES (RELEVANT)—TASK FORCE 2: PEDIATRIC CARDIOLOGY FELLOWSHIP TRAINING IN NONINVASIVE CARDIAC IMAGING

| Committee Member | Employment | Consultant | Speakers Bureau | Ownership/ Partnership/ Principal | Personal Research | Institutional/ Organizational or Other Financial Benefit | Expert Witness |
|---|---|---|---|---|---|---|---|
| Shubhika Srivastava *(Co-Chair)* | Icahn School of Medicine—Professor of Pediatrics; Mount Sinai Medical Center—Director, Congenital, Pediatric and Fetal Echocardiography | None | None | None | None | None | None |
| Beth F. Printz *(Co-Chair)* | Rady Children's Hospital of San Diego—Associate Professor of Clinical Pediatrics and Associate Adjunct Professor of Radiology; University of California San Diego—Medical Director, Echocardiography and Non-Invasive Cardiac Imaging | None | None | None | None | None | None |
| Tal Geva | Harvard Medical School—Professor of Pediatrics; Boston Children's Hospital—Chief, Division of Noninvasive Cardiac Imaging, Department of Cardiology | None | None | None | None | None | None |
| Peter Lang | Boston Children's Hospital—Senior Associate in Cardiology and Director Emeritus, Fellowship Training Program in Pediatric Cardiology and Cardiovascular Research; Harvard Medical School—Associate Professor of Pediatrics | None | None | None | None | None | None |
| Girish S. Shirali | Children's Mercy Hospital and Clinics—Melva and Randall L. O'Donnell, PhD, Chair in Pediatric Cardiology and Division Director, Cardiology; Ward Family Heart Center—Co-Director; University of Missouri—Professor of Pediatrics | None | None | None | None | None | None |
| Paul M. Weinberg | Children's Hospital of Philadelphia—Professor of Pediatrics and Professor of Pediatric Pathology and Laboratory Medicine; The Children's Hospital of Philadelphia—Associate Professor of Radiology; Perelman School of Medicine at the University of Pennsylvania—Past Training Program Director, Pediatric Cardiology | None | None | None | None | None | None |
| Pierre C. Wong | Children's Hospital of Los Angeles—Director, Echocardiography; Keck School of Medicine, University of Southern California—Associate Professor of Pediatrics | None | None | None | None | None | None |

For the purpose of developing a general cardiology training statement, the American College of Cardiology (ACC) determined that no relationships with industry (RWI) or other entities were relevant. This table reflects authors' employment and reporting categories. To ensure complete transparency, authors' comprehensive healthcare-related disclosure information—including RWI not pertinent to this document—is available in an online data supplement. Please refer to http://www.acc.org/guidelines/about-guidelines-and-clinical-documents/relationships-with-industry-policy for definitions of disclosure categories, relevance, or additional information about the ACC Disclosure Policy for Writing Committees.

## APPENDIX 2. PEER REVIEWER RELATIONSHIPS WITH INDUSTRY AND OTHER ENTITIES (RELEVANT)—TASK FORCE 2: PEDIATRIC CARDIOLOGY FELLOWSHIP TRAINING IN NONINVASIVE CARDIAC IMAGING

| Name | Employment | Representation | Consultant | Speakers Bureau | Ownership/ Partnership/ Principal | Personal Research | Institutional/ Organizational or Other Financial Benefit | Expert Witness |
|---|---|---|---|---|---|---|---|---|
| Craig Fleishman | The Heart Center at Arnold Palmer Hospital for Children—Director, Noninvasive Cardiac Imaging | SOPE | None | None | None | None | None | None |
| Regina Lantin-Hermoso | Texas Children's Hospital | ACC ACPC Council | None | None | None | None | None | None |
| Leo Lopez | Miami Children's Hospital—Medical Director of Noninvasive Cardiac Imaging | Content Expert; Chair, ASE Council on Pediatric and Congenital Heart Disease | None | None | None | None | None | None |
| Swee Chye Quek | National University of Singapore, Department of Pediatrics | ACC ACPC Council | None | None | None | None | None | None |
| Geetha Raghuveer | Children's Mercy Hospital, Department of Cardiology | ACC BOG | None | None | None | None | None | None |
| Craig Sable | Children's National Medical Center—Training Director | AHA | None | None | None | None | None | None |
| Ritu Sachdeva | Sibley Heart Center—Medical Director, Cardiovascular Imaging Research Core | AAP | None | None | None | None | None | None |
| Timothy Slesnick | Emory University—Assistant Professor, Pediatric Cardiology | AHA | None | None | None | None | None | None |
| Carole Warnes | Mayo Clinic—Professor, Medicine | ACC BOT | None | None | None | None | None | None |
| Eric S. Williams | Indiana University School of Medicine—Professor (Cardiology) and Associate Dean; Indiana University Health—Cardiology Service Line Leader | ACC CMC Lead Reviewer | None | None | None | None | None | None |
| Luciana Young | Ann and Robert H. Lurie Children's Hospital of Chicago | ACC ACPC Council | None | None | None | None | None | None |

For the purpose of developing a general cardiology training statement, the ACC determined that no relationships with industry or other entities were relevant. This table reflects peer reviewers' employment, representation in the review process, as well as reporting categories. Names are listed in alphabetical order within each category of review. Please refer to http://www.acc.org/guidelines/about-guidelines-and-clinical-documents/relationships-with-industry-policy for definitions of disclosure categories, relevance, or additional information about the ACC Disclosure Policy for Writing Committees.

AAP indicates American Academy of Pediatrics; ACC, American College of Cardiology; ACPC, Adult Congenital and Pediatric Cardiology; AHA, American Heart Association; BOG, Board of Governors; BOT, Board of Trustees; CMC, Competency Management Committee; and SOPE, Society of Pediatric Echocardiography.

## APPENDIX 3. CORE CURRICULAR COMPETENCIES AND EVALUATION TOOLS FOR NONINVASIVE IMAGING

### MEDICAL KNOWLEDGE

- Know the physical properties of ultrasound and Doppler principles.
- Know the principles of echocardiographic image construction and the factors that influence image composition.
- Know the ultrasound imaging devices, including "knobology," appropriate transducer and settings to optimize images, and proper and safe use of the ultrasound equipment.
- Know the proper use of different echocardiographic techniques (2D, M-mode, 3D, color, and spectral Doppler) to thoroughly evaluate cardiac anatomy, physiology, and function.
- Know standard transthoracic imaging planes (subcostal, apical, parasternal, suprasternal).
- Know the effects of patient positioning on image acquisition and how to move them to optimize echocardiographic images.
- Know the indications for pediatric TTE.
- Know the hemodynamic and physiologic changes from fetus to adult.
- Know the full spectrum of pediatric cardiac surgical procedures, including the components of a complete preoperative and postoperative echocardiographic assessment, as well as potential postoperative complications of each procedure.
- Know the techniques for imaging abnormal situs and dextrocardia, as well as the associated terminology of complex disease.
- Know basic TEE imaging views and indications, including the use of TEE for guidance of intraoperative and catheter-based interventions, and be aware of limitations of TEE imaging.
- Know basic fetal imaging views and indications and limitations of fetal echocardiographic imaging.
- Know the basic principles used to generate MR images.
- Know the indications and contraindications for cardiac MR in patients with CHD, including children and adults.
- Know the indications and contraindications for cardiac MR in children with acquired heart disease.

*Evaluation Tools: direct observation, conference participation and presentation, and in-training examination*

### PATIENT CARE OR PROCEDURAL SKILLS

- Have the skills to do a clinical history, know the indications for study, review prior studies, and interim procedures.
- Have the skills to identify the goals of each study.
- Have the skills to consistently obtain adequate images from all planes on a standard TTE in a timely manner.
- Have the skills to identify cardiac structures displayed by echocardiography and how echocardiographic images correlate with cardiac anatomy.
- Have the skills to recognize imaging artifacts.
- Have the skills to obtain appropriate measurements of ventricular, valvar, and vascular dimensions.
- Have the skills to obtain appropriate measures of ventricular function.
- Have the skills to evaluate valvar stenosis and regurgitation with spectral (pulsed and continuous wave) and color Doppler.
- Have the skills to identify and describe common lesions: atrial septal defect, ventricular septal defect, patent ductus arteriosus, aortic stenosis, and pulmonary stenosis.
- Have the skills to complete a full examination of patients with simple congenital defects, including full Doppler assessment, along with a detailed, concise report.
- Have the skills to perform a comprehensive 2D and Doppler examination of a newborn with previously undiagnosed complex congenital heart disease and be able to assess need for prostaglandin without assistance. Complete description of complex anatomic details is encouraged, but not required of a trainee completing core fellowship; accurate imaging/interpretation of complex CHD may require advanced training and/or postfellowship experience.
- Have the skills to identify and describe pericardial disease.
- Have the skills to demonstrate familiarity with indications, use, and limitations of TEE.
- Have the skills to demonstrate familiarity with indications, use, and limitations of basic imaging skills for fetal echocardiography.
- Have the skills to read basic cardiac MR images acquired in infants, children, and young adults with either structurally normal or abnormal hearts.

*Evaluation Tools: conference participation, direct observation, and procedure logs*

2D indicates 2-dimensional; 3D, 3-dimensional; CHD, congenital heart disease; MR, magnetic resonance; TEE, transesophageal echocardiography; and TTE, transthoracic echocardiography.

## APPENDIX 4. REVIEW OF CURRENT PRACTICES

Prior to initiating a revision to the existing training guidelines, a survey was sent out by our subcommittee via e-mail to all pediatric cardiology fellowship program directors. The survey asked for details of the individual program's noninvasive imaging core fellowship training experience, including the numbers of echocardiograms required to be performed by the fellow to successfully complete their noninvasive imaging core fellowship training, how these studies are monitored, and metrics/methods for fellow training assessment. Programs were also asked for their total annual number of TTE, TEE, and fetal echocardiograms, as well as the number of cardiac MRIs and CTs performed the prior year at their institution, and for the number of core and advanced imaging fellows at that institution. Of the 54 programs contacted, responses were received from 33. The results of the survey were as follows:

### TRAINING PROGRAM REQUIREMENTS OF FELLOWS TO SUCCESSFULLY COMPLETE CORE TRAINING IN ECHOCARDIOGRAPHY

- All programs require that their fellows complete 300 echocardiographic procedures, and 8 required them to perform >300. Of these, 2 programs require 500 per trainee. Only 12 programs actually tracked echocardiograms performed by age and complexity.
- Thirteen programs require that their fellows graduating after 3 years of core training should be able to perform and interpret fetal echocardiograms based on the fellow's participation in an average of 50 fetal studies.
- Twenty programs reported all graduating fellows were expected to be able to perform TEEs with an average requirement of 36 procedures (range 10 to 100 procedures).
- Sixteen programs had a formal training program in MRI and only 1 in cardiac CT.
- Twenty-six programs reported that all of their graduating fellows who pursued a career in a nonacademic setting were able to perform and interpret fetal echocardiograms and complex TTEs independently.

### EVALUATION SYSTEM

- All echocardiographic procedure logs were obtained from either the reporting system used (n = 10) or the digital archiving system (n = 23). Few programs required fellows to maintain their own logs.
- Most programs assess performance of a fellow on direct observation of skills, and 18 have an established separate questionnaire, OSCE (objective structured clinical examination) tool, or direct quizzing tool that they use during echocardiography conferences that are focused on assessment of knowledge.
- Eight programs reported use of a self-assessment tool.

The results of the survey suggested that in the current environment, all fellows were being trained using current digital acquisition and storage platforms, and the requirement for number of echocardiograms performed per fellow are based on the existing RRC-ACGME requirements. Additionally, size of the echocardiographic volume per program did not impact the number of expected procedures to be logged by a fellow.

CT indicates computed tomography; MRI, magnetic resonance imaging; RRC-ACGME, Residency Review Committee-Accreditation Council for Graduate Medical Education; TEE, transesophageal echocardiography; and TTE, transthoracic echocardiography.

## APPENDIX 5. RECOMMENDED MINIMUM PROCEDURAL NUMBERS FOR COMPETENCY ASSESSMENT

| Procedure | Recommended Minimum Number |
|---|---|
| **Core Training** | |
| TTE perform and interpret | 150 |
| TTE review and interpret | 100 |
| **Advanced Training** | |
| TTE perform and interpret | 100 |
| TTE review and interpret | 100 |
| TEE perform and interpret | 50 |
| *Fetal echocardiogram perform and interpret | 50 |
| *Fetal echocardiogram review and interpret | 50 |
| Cardiac MRI perform and interpret | 50 |
| Cardiac MRI review and interpret | 50 |

*Fetal echocardiogram: 50 should have congenital heart disease and/or abnormality of fetal circulation.

MRI indicates magnetic resonance imaging; TEE, transesophageal echocardiography; and TTE, transthoracic echocardiography.

JOURNAL OF THE AMERICAN COLLEGE OF CARDIOLOGY
© 2015 BY THE SOCIETY OF PEDIATRIC CARDIOLOGY TRAINING PROGRAM DIRECTORS, AMERICAN COLLEGE OF CARDIOLOGY FOUNDATION, AMERICAN ACADEMY OF PEDIATRICS, AND THE AMERICAN HEART ASSOCIATION, INC.
PUBLISHED BY ELSEVIER INC.

VOL. 66, NO. 6, 2015
ISSN 0735-1097/$36.00
http://dx.doi.org/10.1016/j.jacc.2015.03.012

TRAINING STATEMENT

# Task Force 3: Pediatric Cardiology Fellowship Training in Cardiac Catheterization

*Endorsed by the Society for Cardiovascular Angiography and Interventions*

Laurie B. Armsby, MD, FAAP, FSCAI, *Co-Chair*
Robert N. Vincent, MD, CM, FACC, FSCAI, *Co-Chair*
Susan R. Foerster, MD, FSCAI
Ralf J. Holzer, MD, FSCAI
John W. Moore, MD, MPH, FAAP, FACC, FSCAI
Audrey C. Marshall, MD
Larry Latson, MD, FAAP, FACC, FSCAI
Michael Brook, MD

## 1. INTRODUCTION

### 1.1. Document Development Process

The Society of Pediatric Cardiology Training Program Directors (SPCTPD) board assembled a Steering Committee that nominated 2 chairs, 1 SPCTPD Steering Committee member, and 5 additional experts from a wide range of program sizes, geographic regions, and subspecialty focuses. Representatives from the American College of Cardiology (ACC), American Academy of Pediatrics (AAP), and American Heart Association (AHA) participated. The Steering Committee member was added to provide perspective to each Task Force as a "nonexpert" in that field. Relationships with industry and other entities were not deemed relevant to the creation of a general cardiology training statement; however, employment and affiliation information for authors and peer reviewers are provided in Appendixes 1 and 2, respectively, along with disclosure reporting categories. Comprehensive disclosure information for all authors, including relationships with industry and other entities, is available as an online supplement to this document.

The writing committee developed the document, approved it for review by individuals selected by the participating organizations (Appendix 2), and addressed their comments. The final document was approved by the SPCTPD, AAP, and AHA, as well as endorsed by the Society for Cardiovascular Angiography and Interventions (SCAI) in February 2015 and approved by ACC in March 2015. This document is considered current until the SPCTPD revises or withdraws it.

### 1.2. Background and Scope

Although diagnostic indications for catheterization are less frequent as a result of advances in noninvasive cardiac imaging, innovations in equipment and technologies continue to expand the role of interventional catheterization in the treatment of pediatric and congenital heart disease. The increasing complexity of cardiac catheterization procedures, hybrid approaches to integration of cardiothoracic surgery and transcatheter intervention, and the ability to support hemodynamically vulnerable patients through complex transcatheter procedures requires a high level of proficiency. Although all pediatric cardiology fellows must understand the indications, risks, benefits, and limitations of cardiac

The American College of Cardiology requests that this document be cited as follows: Armsby LB, Vincent RN, Foerster SR, Holzer RJ, Moore JW, Marshall AC, Latson L, Brook M. Task force 3: pediatric cardiology fellowship training in cardiac catheterization. J Am Coll Cardiol 2015;66:699-705.

This article is copublished in *Circulation*.

catheterization, as well as acquire proficiency in assessment and utilization of the data generated through these procedures, not all fellows require the same degree of competence in performing cardiac catheterizations. The challenge inherent in the development of training guidelines for this subspecialty is that they provide sufficient instruction and experience to 2 groups of trainees: those who will continue to perform cardiac catheterizations after fellowship, and those who will not. A further challenge shared by all Task Forces is the paradox of the increasing knowledge base and complexity across all aspects of pediatric cardiology with the static total duration of fellowship training, and reduced in-hospital time because of current duty hour regulations.

The current training guidelines aim to address these challenges through a departure from the earlier focus on a minimum number of procedures, upon which the 2005 guidelines were based (1), to a training model in which proficiency of core concepts within the subspecialty are emphasized. The 3-year training experience should ensure achievement of competencies along a developmental continuum of performance, culminating in complete entrustment of professional activities expected for graduation involving the understanding of data generated by cardiac catheterization procedures.

Our revised training recommendations describe the program resources and environment that are required for training pediatric cardiology fellows, together with a competency-based system promulgated by the American College of Graduate Medical Education (ACGME), to implement specific goals and objectives for training pediatric cardiology fellows. This system categorizes competencies into 6 core competency domains: Medical Knowledge, Patient Care and Procedural Skills, Systems-Based Practice, Practice-Based Learning and Improvement, Professionalism, and Interpersonal and Communication Skills, along with identification of suggested evaluation tools for each domain. Core competencies unique to pediatric cardiac catheterization are listed in Section 3 (see the "2015 SPCTPD/ACC/AAP/AHA Training Guidelines for Pediatric Cardiology Fellowship Programs [Revision of the 2005 Training Guidelines for Pediatric Cardiology Fellowship Programs]: Introduction" for additional competencies that apply to all Task Force reports).

### 1.3. Levels of Expertise—Core and Advanced

Innovations in the field of interventional cardiology have led to increasingly complex procedures in patients who are often hemodynamically vulnerable. Given the potential for great benefit as well as risk, physicians performing these procedures should be skilled in all aspects of diagnostic and therapeutic cardiac catheterization. However, because only a small percentage of pediatric cardiology fellows will ultimately perform cardiac catheterization procedures at the completion of their general pediatric cardiology training, the concept that proficiency with physical catheter manipulation and specific interventional catheterization techniques is mandatory to the general pediatric cardiologist is no longer substantiated.

In this statement, we discuss core training for all fellows enrolled in a traditional 3-year pediatric cardiology fellowship and advanced training for fellows who wish to embark on a career as a pediatric and congenital cardiac interventionalist. Core training is required for all trainees and is intended to ensure that fellows acquire the knowledge base and skills necessary to become a pediatric cardiologist referring his/her patient for cardiac catheterization. Advanced training guidelines are recommended for fellows who wish to specialize in cardiac catheterizations following training.

## 2. PROGRAM RESOURCES AND ENVIRONMENT

Training in pediatric and congenital cardiac catheterization should occur within a pediatric cardiology fellowship program accredited by the ACGME. The cardiac catheterization laboratory should be supported by facilities and units providing expertise in the treatment of children with congenital and acquired heart disease, including cardiac, pediatric, and neonatal intensive care units; an active cardiac surgical program; adequate cardiac imaging services; and outpatient facilities. The pediatric cardiac catheterization laboratory should be under the supervision of a designated pediatric and congenital interventional cardiologist who has primary responsibility for supervision of the laboratory. Catheterization equipment and inventory should be maintained to ensure high-quality performance and to comply with regulations and guidelines for patient safety. A minimum of 150 diagnostic and/or interventional catheterizations must be performed in the laboratory per year to provide an adequate learning environment (2).

The director of the cardiac catheterization program should maintain a curriculum of training within the catheterization laboratory. This should include regular teaching conferences and morbidity and mortality conferences in which all adverse events related to catheterization are systematically reviewed in the presence of representatives from all constituents of the congenital cardiac program. In addition, there should be an established process for discussion of patient data, as well as indications for, and expected findings and objectives of, the procedure prior to each catheterization. The cardiac catheterization laboratory should maintain active involvement in quality improvement programs, including evaluation of outcomes, a record of adverse events, and, if possible, participation in a national pediatric and congenital cardiac catheterization registry (2).

**TABLE 1** Core Curricular Competencies and Evaluation Tools for Pediatric and Congenital Cardiac Catheterization

**Medical Knowledge**
- Know the risks and benefits of catheterization and specific interventions.
- Know the indications and contraindications for catheterization and specific interventions.
- Know procedural techniques for catheterization and specific interventions.
- Know the principles of radiation safety.

*Evaluation Tools: direct observation, conference participation and presentation, procedure logs, and in-training examination*

**Patient Care and Procedural Skills**
- Have the skills to interpret waveforms, determination of pressures, and gradients.
- Have the skills to apply thermodilution and the Fick principle for flows and resistances.
- Have the skills to recognize normal and abnormal hemodynamics.
- Have the skills to interpret angiographic information.
- Have the skills to assess interventional outcomes, both successful and unsuccessful.
- Have the skills to assess the limitations of a procedure and to recognize and manage complications.

*Evaluation Tools: direct observation, conference participation, and procedure logs*

**Interpersonal and Communication Skills**
- Effectively communicate catheterization data, both orally and in written form.

*Evaluation Tools: direct observation, faculty evaluations, and 360 evaluations*

## 3. CORE TRAINING: GOALS AND METHODS

We have substantially revised the requirement delineated in the 2005 training guidelines that the pediatric cardiology fellow participate as primary operator or primary assistant in 100 catheterizations, at least 20 of which include an interventional component. The current guidelines replace the emphasis on performing a minimum number of procedures with demonstration of achievement of competencies within cardiac catheterization (Table 1). The acquisition of a number of catheterization-specific competencies over the course of training will be assessed with explicit milestones currently being developed by SPCTPD in conjunction with the American Board of Pediatrics.

Instruction in catheterization-specific cardiac anatomy, cardiac physiology, and transcatheter diagnostic and interventional cardiology should be included in the 3-year core training experience. By completion of training the individual should understand, and be capable of independently explaining the indications, risks, benefits, and limitations of cardiac catheterization as a diagnostic modality and as a therapeutic option for specific lesions. To appropriately risk stratify patients, they should have a working knowledge of the principles of radiation exposure and safety.

The fellow should be expert in interpreting hemodynamic and angiographic data acquired through cardiac catheterization. This includes recognition of abnormal hemodynamic and angiographic findings; an ability to perform hemodynamic calculations, including cardiac output, flow relationships, pressure gradients, and vascular resistance; and the application of hemodynamic data to physiological principles. In addition, the fellow will have a contemporary understanding of the basic methodologies of transcatheter intervention for valvuloplasty, arterio/venoplasty, device closure, stent placement, and emergent procedures. The fellow will be capable of assessing the outcome of an intervention. This includes recognition of residual hemodynamic or anatomic perturbations, device stability, and evaluation of radiographic and echocardiographic studies pertinent to an intervention. The fellow should be capable of evaluating patients presenting with symptoms of complications that could be attributable to a transcatheter intervention.

These competencies shall be acquired through clinical exposure and experience with a required minimum number of catheterization procedures during core fellowship training. Although the variability in which trainees achieve competencies in cardiac catheterization is significant, the requirement of a minimum number of procedures serves to provide an appropriate exposure to the field and establish an accurate assessment of competence. The core training curriculum should require that all fellows act as an assistant to the attending interventional cardiologist in a minimum of 50 cardiac catheterizations. The assistant's role for this purpose is defined as an active participant in the procedure, who is surgically scrubbed and has direct contact with the patient and equipment. Those fellows showing an interest in or an affinity for catheterization should be encouraged to participate in many more cases over the 3 years. In addition to assisting in the procedure, the fellow should also participate in case preparation and postprocedural care, including monitoring and managing complications, hemodynamic calculations, interpretation of angiography, report generation, and communication of the findings to his or her interdisciplinary colleagues. Fellows should actively participate in quality improvement activities, including morbidity and mortality conferences specific to interventional cardiology.

## 4. ADVANCED TRAINING: GOALS AND METHODS

To attain verification of competence to practice interventional cardiology without supervision at completion of training, an additional year or more of advanced training in pediatric and congenital interventional catheterization following the standard core fellowship should be mandatory (3–5). During this year, individuals would be required to perform procedures of gradually increasing complexity under the supervision of an attending interventional cardiologist. The Congenital Heart Disease Section of SCAI has created an expert consensus statement for advanced training in pediatric

and congenital interventional cardiac catheterization, and the details of these specifics can be found in this report (3). We have summarized the key points here.

In general, the fellow undergoing advanced training in pediatric and congenital cardiac catheterization should attain a greater experience and level of independence of the core competencies in Table 1. In addition, advanced fellows should become highly skilled in the technical aspects of cardiac catheterization. Attaining advanced-level skills in pediatric and congenital cardiac catheterization requires that the trainee act as primary operator under the supervision of an attending interventionalist in all of the major categories of pediatric and congenital cardiac catheterization procedures available at the training institution. Achievement of competence toward complete entrustment should be measured, monitored, and documented during the advanced training curriculum. At a minimum, it is expected that extensive instruction would be provided in the following procedural categories:

- Complex vascular access
- Aortic and pulmonary valvuloplasties
- Angioplasty of the aorta, pulmonary arteries, and systemic and pulmonary veins
- Emergent procedures such as balloon atrial septostomy and left atrial decompression
- Use of stents with deployment in the pulmonary arteries, aorta, and other vessels
- Use of closure devices including vascular plugs/coils, especially for the treatment of atrial and ventricular septal defects, fenestrations, and patent ductus arteriosus
- Endomyocardial biopsy
- Pericardiocentesis/creation of a pericardial window

Exposure to novel and complex techniques such as transcatheter valve implantation and radiofrequency valve perforation is ideal but may be limited by institutional preference and availability.

The Task Force recognizes that many catheter techniques are similar, and that seasoned interventionalists use previously mastered skills to further their acquisition of new techniques throughout their career. We also acknowledge that technical skills continue to develop throughout an interventional career and recognize the value of continued professional growth and mentorship by a senior colleague, when available, after subspecialty training. Fellows participating in advanced training for pediatric and congenital cardiac catheterization should perform the minimum number of procedures recommended in Table 2 to meet advanced training standards.

**TABLE 2 Advanced Training Requirements for Pediatric and Congenital Cardiac Catheterization**

| Procedure | Minimum Number of Procedures |
|---|---|
| Cardiac catheterization (including interventions) | 250 |
| Interventional procedures (including those listed below) | 150 |
| Interventional procedures in neonate (≤30 days of age) | 25 |
| Device closures (ASD, VSD, PDA, PFO, and others using closure devices and plugs) | 30 |
| Angioplasty procedures | 30 |
| Stent insertion | 20 |
| Transseptal punctures | 5 |
| Procedures to open the atrial septum | 5 |

ASD indicates atrial septal defect; PDA, patent ductus arteriosus; PFO, patent foramen ovale; and VSD, ventricular septal defect.

## 5. SPECIFIC PROGRAM CONTENT: CORE AND ADVANCED LEVELS

Trainees will be expected to develop an appropriate level of knowledge and experience in each of the areas below.

- Know the indications for catheterization. *All fellows* should understand the appropriate indications for undertaking the risk of cardiac catheterization. This requires an understanding of the physiological principles underlying the hemodynamic data collected during the procedure and facility in the appropriate application of that data to clinical decision making. Alternatives to acquiring diagnostic information must be understood and compared to the quality and risks of data acquisition during catheterization. Alternatives to interventional catheterization procedures must be understood and compared to the quality and risks of transcatheter interventions.
- Know the risks of catheterization and specific interventions. *All fellows* should understand the potential complications associated with acquisition of hemodynamic and angiographic data by catheterization. In addition, all fellows should have a contemporary working knowledge of the risks, complications, and limitations of transcatheter interventions. All fellows should actively participate in morbidity and mortality conferences in which complications of catheterization are analyzed and discussed in the presence of subspecialists across pediatric cardiology. *Advanced trainees* should have hands-on experience managing complications encountered during the major categories of interventional procedures.
- Know the interpretation of waveforms and determination of pressures and gradients. *All fellows* should be proficient at using the raw hemodynamic data collected at catheterization to determine cardiopulmonary physiology and pathophysiology for all congenital cardiac defects and acquired pediatric heart disease.

- Know the application of thermodilution, the Fick principle, and resistances. *All fellows* should understand the principles of flow, pressure, and resistance measurements and calculations acquired at catheterization, as well as the assumptions and limitations inherent in their determination. Fellows should understand how these elements are derived, how they interrelate, and how they are appropriately applied to clinical decision making. They should understand provocative testing for pulmonary vascular reactivity and the concepts of oxygen content and oxygen consumption.
- Have the skills to analyze hemodynamic data collected at catheterization. *All fellows* should know the normal cardiopulmonary hemodynamics and understand the physiological causes and implications of abnormal hemodynamics. Fellows should also understand the implication of level of sedation and mode and level of ventilation on the cardiopulmonary hemodynamics measured at catheterization.
- Know procedural technique. *All fellows* must have a conceptual knowledge of the process of vascular access, catheter manipulation, anatomic relationships, and data acquisition in a wide range of congenital cardiac and pediatric acquired heart disease. *Advanced fellows* should be expert in each of these areas, recognizing that further expertise will develop with experience and technological advancement.
- Have the skills to interpret angiographic information. *All fellows* should be skilled in recognizing basic cardiopulmonary anatomic structures delineated through angiography. They should be able to appreciate normal and abnormal anatomic details in a wide range of congenital heart defects. Fellows should also know the basic principles of angiography, including a working knowledge of catheter positioning, camera angles, and contrast toxicity. *Advanced fellows* should be expert at interpreting angiographic information. They should be proficient in recognizing complex cardiopulmonary anatomic structures both preoperatively and postoperatively. In addition, they should be able to independently capture appropriate and high-quality angiographic images in all patients with congenital heart disease.
- Know how to assess interventional outcomes. *All fellows* should have a working knowledge of the indications, associated risks, and anticipated outcome for all transcatheter interventions. In addition, all fellows should have a basic understanding of safety and efficacy criteria for terminating efforts at intervention. They should understand and be able to interpret the results and requirements for noninvasive and/or invasive follow-up.
- Effectively communicate catheterization data, verbally and written. *All fellows* should be competent in succinctly articulating the essential information of a cardiac catheterization. They should be able to summarize and explain the findings to a wide range of associates including patients/parents, nurses, noncardiac practitioners, cardiologists, and surgeons. Fellows should be given ample opportunity to present data in a variety of settings during their training.
- Know the principles of radiation safety. *All fellows* should be able to demonstrate a working comprehension of the principles of radiation safety, including the methods of risk reduction during cardiac catheterization. They should know the quantities of radiation necessary for catheterization procedures, as well as for alternative imaging modalities. *Advanced fellows* should be expert in these concepts and be facile in utilization and instruction of the principles of radiation safety principles.

## 6. EVALUATION AND DOCUMENTATION OF COMPETENCE

All training programs should include written goals and objectives for each cardiac catheterization rotation with performance goals set according to the fellow's level of training. These will serve as the basis for formative feedback. A copy of these goals and objectives should be supplied and explained to the trainee at the onset of fellowship training and reviewed at the beginning of each rotation. Evaluation of fellows should be performed midway through, and at the completion of, each rotation; evaluations should be directed toward whether the fellow met those prespecified aims. The fellow evaluation should be performed by the cardiac catheterization laboratory director and/or senior cardiac catheterization physician chosen as director of cardiac catheterization training. The fellow evaluation should assess the fellow's performance in each of the 6 areas of core competencies, as appropriate for the level of training, and should be based on direct observation of the fellow. Evaluation of competency in preparation, performance, and interpretation of the results of a procedure should be given more consideration than a focus on the number of procedures performed. Evaluation of competency should be done in person with the trainee and documented in his or her fellowship record. If the trainee is not progressing as expected, remedial actions should be arranged and documented in accordance with institutional procedures. All fellows should maintain a log (preferably electronic) of all procedures performed.

## REFERENCES

**1.** Beekman RH III, Hellenbrand WE, Lloyd TR, et al. ACCF/AHA/AAP recommendations for training in pediatric cardiology. Task force 3: training guidelines for pediatric cardiac catheterization and interventional cardiology. J Am Coll Cardiol. 2005; 46:1388–90.

**2.** Bashore TM, Balter S, Barac A, et al. 2012 American College of Cardiology Foundation/Society for Cardiovascular Angiography and Interventions expert consensus document on cardiac catheterization laboratory standards update: a report of the American College of Cardiology Foundation Task Force on Expert Consensus Documents. J Am Coll Cardiol. 2012;59: 2221–305.

**3.** Armsby L, Beekman RH III, Benson L, et al. SCAI expert consensus statement for advanced training programs in pediatric and congenital interventional cardiac catheterization. Catheter Cardiovasc Interv. 2014;84:779–84.

**4.** Ruiz CE, Mullins CE, Rochini AP, et al. Core curriculum for the training of pediatric invasive/interventional cardiologists: report of the Society for Cardiac Angiography and Interventions Committee on Pediatric Cardiology Training Standards. Cathet Cardiovasc Diagn. 1996;37:409–24.

**5.** Harold JG, Bass TA, Bashore TM, et al. ACCF/AHA/SCAI 2013 update of the clinical competence statement on coronary artery interventional procedures: a report of the American College of Cardiology Foundation/American Heart Association/American College of Physicians Task Force on Clinical Competence and Training (Writing Committee to Revise the 2007 Clinical Competence Statement on Cardiac Interventional Procedures). J Am Coll Cardiol. 2013;62:357–96.

**KEY WORDS** SPCTPD/ACC/AAP/AHA Training Statement, cardiac catheterization—diagnostic and interventional, clinical competence, fellowship training, pediatric cardiology

## APPENDIX 1. AUTHOR RELATIONSHIPS WITH INDUSTRY AND OTHER ENTITIES (RELEVANT)—TASK FORCE 3: PEDIATRIC CARDIOLOGY FELLOWSHIP TRAINING IN CARDIAC CATHETERIZATION

| Committee Member | Employment | Consultant | Speakers Bureau | Ownership/ Partnership/ Principal | Personal Research | Institutional/ Organizational or Other Financial Benefit | Expert Witness |
|---|---|---|---|---|---|---|---|
| Laurie B. Armsby *(Co-Chair)* | Oregon Health Sciences University—Associate Professor of Pediatrics; Division Head, Pediatric Cardiology; Director, Pediatric Cardiology Fellowship Program | None | None | None | None | None | None |
| Robert N. Vincent *(Co-Chair)* | Emory University School of Medicine—Professor of Pediatrics | None | None | None | None | None | None |
| Susan R. Foerster | Children's Hospital of Wisconsin/Medical College of Wisconsin—Medical Director, Interventional Cardiology | None | None | None | None | None | None |
| Ralf J. Holzer | Sidra Medical & Research Center, Sidra Cardiovascular Center of Excellence—Medical Director, Cardiac Catheterization & Interventional Therapy | None | None | None | None | None | None |
| John W. Moore | Rady Children's Hospital—Director of Cardiology; University of California School of Medicine—Professor of Pediatrics | None | None | None | None | None | None |
| Audrey C. Marshall | Harvard University—Associate Professor of Pediatrics; Boston Children's Hospital—Senior Associate of Cardiology; Chief, Invasive Cardiology; Director, Cardiac Catheterization Laboratory | None | None | None | None | None | None |
| Larry Latson | Joe DiMaggio Children's Hospital/Memorial Healthcare System—Director, Congenital Cardiac Catheterization Laboratory; Director, Adult Congenital Heart Defects Program; Florida Atlantic University Medical School—Clinical Professor | None | None | None | None | None | None |
| Michael Brook | University of California-San Francisco—Professor of Pediatrics; Director, Pediatric Echocardiography; Director, Pediatric Cardiology Fellowship Training | None | None | None | None | None | None |

For the purpose of developing a general cardiology training statement, the American College of Cardiology (ACC) determined that no relationships with industry (RWI) or other entities were relevant. This table reflects authors' employment and reporting categories. To ensure complete transparency, authors' comprehensive healthcare-related disclosure information—including RWI not pertinent to this document—is available in an online data supplement. Please refer to http://www.acc.org/guidelines/about-guidelines-and-clinical-documents/relationships-with-industry-policy for definitions of disclosure categories, relevance, or additional information about the ACC Disclosure Policy for Writing Committees.

## APPENDIX 2. PEER REVIEWER RELATIONSHIPS WITH INDUSTRY AND OTHER ENTITIES (RELEVANT)—TASK FORCE 3: PEDIATRIC CARDIOLOGY FELLOWSHIP TRAINING IN CARDIAC CATHETERIZATION

| Name | Employment | Representation | Consultant | Speakers Bureau | Ownership/ Partnership/ Principal | Personal Research | Institutional/ Organizational or Other Financial Benefit | Expert Witness |
|---|---|---|---|---|---|---|---|---|
| Eric Bates | The Cardiovascular Center, University of Michigan | CMC | None | None | None | None | None | None |
| Regina Lantin-Hermoso | Texas Children's Hospital | ACC ACPC Council | None | None | None | None | None | None |
| Swee Chye Quek | National University of Singapore, Department of Pediatrics | ACC ACPC Council | None | None | None | None | None | None |
| Jonathan Rome | Children's Hospital of Philadelphia | AHA | None | None | None | None | None | None |
| Carole Warnes | Mayo Clinic—Professor, Medicine | ACC BOT | None | None | None | None | None | None |
| Eric Williams | Indiana University School of Medicine—Professor (Cardiology) and Associate Dean; Indiana University Health, Cardiology Service Line Leader | ACC CMC Lead Reviewer | None | None | None | None | None | None |

For the purpose of developing a general cardiology training statement, the ACC determined that no relationships with industry or other entities were relevant. This table reflects peer reviewers' employment, representation in the review process, as well as reporting categories. Names are listed in alphabetical order within each category of review. Please refer to http://www.acc.org/guidelines/about-guidelines-and-clinical-documents/relationships-with-industry-policy for definitions of disclosure categories, relevance, or additional information about the ACC Disclosure Policy for Writing Committees.

ACC indicates American College of Cardiology; ACPC, Adult Congenital and Pediatric Cardiology; AHA, American Heart Association; BOT, Board of Trustees; and CMC, Competency Management Committee.

JOURNAL OF THE AMERICAN COLLEGE OF CARDIOLOGY
© 2015 BY THE SOCIETY OF PEDIATRIC CARDIOLOGY TRAINING PROGRAM DIRECTORS, AMERICAN COLLEGE OF CARDIOLOGY FOUNDATION, AMERICAN ACADEMY OF PEDIATRICS, AND THE AMERICAN HEART ASSOCIATION, INC.
PUBLISHED BY ELSEVIER INC.

VOL. 66, NO. 6, 2015
ISSN 0735-1097/$36.00
http://dx.doi.org/10.1016/j.jacc.2015.03.005

TRAINING STATEMENT

# Task Force 4: Pediatric Cardiology Fellowship Training in Electrophysiology

*Endorsed by the Pediatric & Congenital Electrophysiology Society*

Anne M. Dubin, MD, FHRS, *Co-Chair*
Edward P. Walsh, MD, FHRS, *Co-Chair*
Wayne Franklin, MD, FAAP, FACC, FAHA
Ronald J. Kanter, MD, FACC, FHRS
J. Philip Saul, MD, FACC, FAHA, FHRS
Maully J. Shah, MBBS, FACC, FHRS
George F. Van Hare, MD, FACC, FHRS
Julie A. Vincent, MD, FAAP, FACC, FSCAI

## 1. INTRODUCTION

### 1.1. Document Development Process

The Society of Pediatric Cardiology Training Program Directors (SPCTPD) board assembled a Steering Committee that nominated 2 chairs, 1 SPCTPD Steering Committee member, and 5 additional experts from a wide range of program sizes, geographic regions, and subspecialty focuses. Representatives from the American College of Cardiology (ACC), American Academy of Pediatrics (AAP), American Heart Association (AHA), and Pediatric and Congenital Electrophysiology Society (PACES) participated. The Steering Committee member was added to provide perspective to each Task Force as a "nonexpert" in that field. Relationships with industry and other entities were not deemed relevant to the creation of a general cardiology training statement; however, employment and affiliation information for authors and peer reviewers are provided in Appendixes 1 and 2, respectively, along with disclosure reporting categories. Comprehensive disclosure information for all authors, including relationships with industry and other entities, is available as an online supplement to this document.

The writing committee developed the document, approved it for review by individuals selected by the participating organizations (Appendix 2), and addressed their comments. The final document was approved by the SPCTPD, AAP, and AHA in February 2015 and approved by the ACC and endorsed by PACES in March 2015. This document is considered current until the SPCTPD revises or withdraws it.

### 1.2. Background and Scope

Pediatric electrophysiology is a rapidly evolving field. New technology for implantable devices and ablations, and advances in the genetic diagnosis of channelopathies challenge the pediatric electrophysiologist. The need for formal guidelines to train the pediatric cardiologist in electrophysiology is readily apparent, with a formal statement from the AHA, ACC, and Heart Rhythm Society (HRS) published in 2005 (1). This initial set of guidelines was derived in part from training guidelines in adult clinical cardiac electrophysiology but recognizes the important difference between the pediatric and adult arrhythmia patient (2).

The American College of Cardiology requests that this document be cited as follows: Dubin AM, Walsh EP, Franklin W, Kanter RJ, Saul JP, Shah MJ, Van Hare GF, Vincent JA. Task force 4: pediatric cardiology fellowship training in electrophysiology. J Am Coll Cardiol 2015;66:706–11.

This article is copublished in *Circulation*.

Pediatric patients differ in important ways from adult patients, as recognized by the separate training programs and board certifications for adult and pediatric cardiologists. The pediatric cardiologist should be able to manage the child with a structurally normal heart and supraventricular tachycardia and the child with a perioperative arrhythmia following congenital heart disease (CHD) repair, as well as be knowledgeable about the fetus with an in utero arrhythmia and where and when to refer. The adult CHD patient offers further challenges. These new guidelines have been modified to reflect the changing practice of pediatric electrophysiology, and stress the need for a working understanding of genetic channelopathies, as well as the importance of a deeper understanding of the indications for—and management of—the present generation of pacemakers, defibrillators, resynchronization devices, and implantable loop recorders.

Our revised training recommendations describe the program resources and environment that are required for training pediatric cardiology fellows, together with a competency-based system promulgated by the American College of Graduate Medical Education (ACGME), to implement specific goals and objectives for training pediatric cardiology fellows. This system categorizes competencies into 6 core competency domains: Medical Knowledge, Patient Care and Procedural Skills, Systems-Based Practice, Practice-Based Learning and Improvement, Professionalism, and Interpersonal and Communication Skills, along with identification of suggested evaluation tools for each domain. Core competencies unique to pediatric cardiac electrophysiology are listed in Section 3 (see the "2015 SPCTPD/ACC/AAP/AHA Training Guidelines for Pediatric Cardiology Fellowship Programs [Revision of the 2005 Training Guidelines for Pediatric Cardiology Fellowship Programs]: Introduction" for additional competencies that apply to all Task Force reports).

### 1.3. Levels of Expertise—Core and Advanced

Core training must be available at all centers with a fellowship program in pediatric cardiology. The core curriculum described in Section 3 is intended to be sufficient for fellows who do not plan a formal career in electrophysiology. Core training is required for all trainees and is intended to ensure that each fellow acquires the knowledge base and skills necessary to become a pediatric cardiologist referring his/her patient for more detailed and invasive rhythm investigation. Advanced training guidelines are designed for fellows who wish to embark on a career that will include invasive electrophysiology procedures. Advanced electrophysiology training should only take place at select centers with a procedural volume that can satisfy the minimum recommended procedural experience (Section 4).

## 2. PROGRAM RESOURCES AND ENVIRONMENT

For training in pediatric electrophysiology, training should be obtained in a center where there is a pediatric cardiology training program accredited by the ACGME. Pediatric catheterization laboratory facilities should be available with the appropriate equipment to perform electrophysiology studies and catheter ablation. Such facilities should include the capability for 3-dimensional electroanatomic mapping and be equipped for both radiofrequency ablation and catheter cryoablation. The program must also have facilities for the implantation of arrhythmia control devices (i.e., pacemakers and implantable cardioverter-defibrillators [ICDs]). In some settings, this will be the pediatric cardiac catheterization laboratory or electrophysiology laboratory, and in others, it may be the operating room. The center's clinical procedural volume must be sufficient to allow for exposure of each trainee to clinical cases in numbers that satisfy trainee procedure volume expectations. Some centers may have inadequate volume in every clinical area to ensure that trainees get adequate exposure in the allotted core training period, particularly when considering exposure to pacemaker and ICD implantation. In such cases, it may be feasible for a trainee to gain this experience at a partner adult institution. At least 1 board-certified pediatric cardiologist with advanced electrophysiology skills should be identified as the director of the pediatric electrophysiology core training program, and at least 1 staff cardiologist and/or cardiac surgeon should be skilled in the implantation of pacemakers and ICDs.

Although third-tier board certification is not available through the American Board of Pediatrics for the subspecialty of pediatric electrophysiology, the International Board of Heart Rhythm Examiners (IBHRE) now offers certification examinations for competency in both pediatric cardiac electrophysiology and cardiac rhythm device therapy. For any center offering *advanced* fellowship training, at least 1 electrophysiology staff member should hold current certification in either (or both) of the IBHRE examinations.

## 3. CORE TRAINING: GOALS AND METHODS

By the completion of the core training period, the trainee should achieve high-level competency in clinical aspects of noninvasive electrophysiology. **Table 1** lists the core curricular competencies for pediatric electrophysiology, along with corresponding evaluation tools. Specifically, they should be able to independently evaluate, treat, and know when to refer young patients with syncope, palpitations, supraventricular arrhythmias, ventricular arrhythmias, atrioventricular conduction disturbances, and all forms of early postoperative arrhythmias. They will have

**TABLE 1 Core Curricular Competencies and Evaluation Tools for Pediatric Electrophysiology**

| |
|---|
| **Medical Knowledge:** |
| ■ Know the cellular and whole-organ electrophysiology. |
| ■ Know the anatomy and embryology of conduction tissues. |
| ■ Know the developmental changes in cardiac rates and rhythm with age. |
| ■ Know the basic mechanism of arrhythmias. |
| ■ Know the clinical presentation and mechanisms of supraventricular tachycardias. |
| ■ Know the clinical presentation and mechanisms of ventricular tachycardias. |
| ■ Know the clinical presentations and mechanisms of channelopathies and hereditary cardiomyopathies. |
| ■ Know the clinical presentations of and mechanisms of bradycardia and atrioventricular block. |
| ■ Know the clinical presentations and diagnoses of fetal arrhythmias. |
| ■ Know the presentations and mechanisms of palpitations, syncope, and sudden cardiac death in the young. |
| ■ Know the specifics for clearance for sports participation. |
| ■ Know the mechanisms and types of arrhythmias in CHD. |
| ■ Know pacing modes, basic pacemaker interrogation, pacemaker or ICD types, and basic trouble-shooting for pacemaker and implantable defibrillator therapy. |
| ■ Know the indications and risks for invasive electrophysiology studies. |
| ■ Know the basic principles of mapping and catheter ablation. |
| ■ Know the indications for arrhythmia surgery. |
| ■ Know the indications for utilizing antiarrhythmic drug therapy. |
| *Evaluation Tools: direct observation, conference participation and presentation, procedure logs, and in-training examination* |
| **Patient Care and Procedural Skills:** |
| ■ Have the skills to utilize ECG, Holter monitoring, exercise testing, and event monitors as diagnostic tools. |
| ■ Have the skills to use pharmacological agents, esophageal or intracardiac pacing, and direct current cardioversion in the acute stabilization of arrhythmias. |
| ■ Have the skills to interpret basic electrophysiology information obtained through electrophysiology studies and catheter ablation therapy. |
| ■ Have the skills to apply adult arrhythmia data to pediatric practice where relevant. |
| *Evaluation Tools: direct observation, conference participation, and procedure logs* |

CHD indicates congenital heart disease; ECG, electrocardiography; and ICD, implantable cardioverter-defibrillator.

developed skills in risk assessment for sudden death in young patients having heritable disorders and in those having worrisome, but nonspecific, symptoms or laboratory findings. They should understand the indications for and be competent in the interpretation of electrocardiograms, ambulatory rhythm monitoring (Holter), and event monitoring. There should be adequate diversity in clinical material, such that patients having pre- and postoperative congenital heart disease are adequately represented.

Basic science knowledge in the core curriculum includes pharmacology, cellular and anatomic electrophysiology, molecular and clinical genetics, and rudimentary physics. This knowledge should be acquired in the context of clinical care, didactic lectures, bedside teaching, and independent reading. This knowledge will be applied to the use of pharmacological agents to treat arrhythmias in the fetus, child, and adolescent and those having CHD, including specific understanding of electrophysiological pharmacodynamics, pharmacokinetics, drug-drug interactions, drug-electrolyte interactions, and side effects; expert knowledge of the anatomy of the conduction system in congenital heart disease; working knowledge of the genetics of channelopathies and cardiomyopathies, the indications to order genetic testing, and general interpretation of the results of genetic testing for such conditions; and basic knowledge of the physics of pacing, cardioversion, defibrillation, and therapeutic ablation of arrhythmia substrates.

The trainee should acquire basic knowledge regarding nonpharmacological electrophysiology, heretofore defined as invasive electrophysiology. Table 2 delineates the recommended minimal procedural experience required to assess competency in pediatric cardiac electrophysiology for both core and advanced training. By the completion of core training, the individual should be capable of managing acute pacing strategies including the use of temporary transvenous pacing catheters, esophageal electrode catheters, and percutaneous surgical wires. This includes skills in interpretation of acute postoperative arrhythmias; management and follow-up of temporary pacing systems; termination of supraventricular tachycardia and/or VT with pacing maneuvers; and indications, techniques, and associated risks (including stroke) of elective and emergent direct current cardioversion. This also includes the ability to determine pacing and sensing thresholds. It is expected that the trainee will have contemporary knowledge of indications, risks, benefits, and limitations of electrophysiological testing and catheter ablation of tachyarrhythmias. They will have general understanding of the diagnostic methods for discriminating arrhythmia types using intracardiac testing, the use of pharmacological agents during testing, principles of substrate mapping, and fundamental risks and methodologies of catheter ablation. They will be capable of interpreting common and straightforward intracardiac electrograms, including electrical interval measurements. These skills will be accomplished by a combination of clinical exposure, conferences, didactic lectures, and supplemental reading.

All trainees should understand the indications for pacemaker and ICD placement, know the differences in pacing modes, be capable of performing basic pacemaker interrogation, be able to perform fundamental reprogramming and troubleshooting, and recognize basic device and lead malfunction. This includes recognition of sensing abnormalities, failure to capture, and battery end-of-service

**TABLE 2** Recommended Minimal Procedural Experience to Assess Competency in Pediatric Cardiac Electrophysiology

| Procedure | "Core" Suggested No. of Procedures | "Advanced" Suggested No. of Procedures |
|---|---|---|
| Noninvasive | | |
| ECG interpretation | 500 | 1500 |
| Holter/event/rhythm strips | 50 | 400 |
| Exercise testing rhythm | 10 | 20 |
| Postoperative epicardial wire/esophageal study | 5 | 20 |
| D/C cardioversion | 4 | 10 |
| Simple electrophysiology studies/ablation | | |
| Diagnostic study | 10 | 10 |
| Ablation for AP and AVNRT | 5 | 50 |
| Complex ablation | | |
| Small/young patients | – | 5 |
| 3D mapping in CHD | – | 10 |
| Intraoperative electrophysiology | | |
| Assist epicardial pacemaker | – | 5 |
| Assist epicardial ICD | – | 3 |
| Intraoperative ablation | – | 3 |
| Simple devices | | |
| Test and program pacemaker/ICD | 20 | 100 |
| TV pacemaker implant/revision | – | 20 |
| TV ICD implant/revision | – | 15 |
| Complex devices | | |
| Implant pacemaker/ICD in young/CHD | – | 10 |
| Resynchronization pacing | – | 5 |
| Lead extraction | – | 5 |

3D indicates 3-dimensional; AP, accessory pathways; AVNRT, atrioventricular nodal re-entrant tachycardia; CHD, congenital heart disease; ECG, electrocardiogram; ICD, implantable cardioverter-defibrillator; and TV, transvenous.

characteristics. The trainee will be able to evaluate the radiographic studies and perform basic device evaluation in young patients presenting with symptoms that could be attributable to device malfunction.

## 4. ADVANCED TRAINING: GOALS AND METHODS

Advanced training guidelines for pediatric electrophysiology were recently reviewed and updated by the Pediatric and Congenital Electrophysiology Society (PACES) and the HRS (3). That publication should be referred to for a comprehensive training syllabus and detailed description of procedural instruction. Included here is a brief synopsis of advanced pediatric electrophysiology training.

The goal of advanced electrophysiology training is to equip new practitioners with the knowledge and technical skills necessary to manage all manner of rhythm disorders in the fetus, infant, child, and adolescent, as well as in adults with CHD. This must involve extensive instruction in invasive procedures, including intracardiac electrophysiological studies, catheter ablation, and implantable devices. The new guidelines for advanced training (3) recognize that learning curves for complex technical skills do not reach a plateau at the moment of graduation from formal instruction but will continue to rise throughout a trainee's early career. Additional mentoring may be required to achieve full competency in certain demanding procedures such as lead extraction and ablation in the setting of complex anatomy.

Trainees entering an advanced fellowship in pediatric electrophysiology must have successfully completed a core fellowship and be eligible for certification by the Cardiology Subboard of the American Board of Pediatrics (or its equivalent). Attaining advanced skills requires 12 months or more of focused training at an accredited high-volume academic center. The program must include instruction in all important bench science and clinical science that underlies the field, with particular emphasis on CHD, developmental influences on rhythm status, and hereditary arrhythmias. This information should be conveyed through a combination of bedside teaching, directed readings, and an organized series of didactic lectures. See Table 2 for a brief summary of the minimal procedural experience required to assess competency for advanced trainees.

## 5. EVALUATION AND DOCUMENTATION OF COMPETENCE

All training programs should include written goals and objectives for each cardiac electrophysiology rotation, with performance goals set according to the fellow's level of training. These will serve as the basis for formative feedback. A copy of these goals and objectives should be supplied and explained to the trainee at the onset of fellowship training and reviewed at the beginning of each rotation. Evaluation of fellows should be performed midway through, and at the completion of, each rotation; evaluations should be directed toward whether the fellow met those prespecified aims. The fellow evaluation should be performed by the cardiac electrophysiology laboratory director and/or senior cardiac electrophysiology physician chosen as director of electrophysiology training. The fellow evaluation should assess the fellow's performance in each of the 6 areas of core competencies, as appropriate for the level of training, and should be based on direct observation of the fellow. Evaluation of competency in preparation, performance, and interpretation of the results of a procedure should be given more consideration than a focus on the number of procedures performed. Evaluation of competency should be done in

person with the trainee and documented in his or her fellowship record. If the trainee is not progressing as expected, remedial actions should be arranged and documented in accordance with institutional procedures. All fellows should maintain a log (preferably electronic) of all procedures performed.

## REFERENCES

**1.** Vetter VL, Silka MJ, Van Hare GF, et al. ACCF/AHA/AAP recommendations for training in pediatric cardiology. Task force 4: recommendations for training guidelines in pediatric cardiac electrophysiology. J Am Coll Cardiol. 2005;46:1391–5.

**2.** Naccarelli GV, Conti JB, DiMarco JP, et al. Task force 6: training in specialized electrophysiology, cardiac pacing, and arrhythmia management. J Am Coll Cardiol. 2008;51:374–80.

**3.** Walsh EP, Bar-Cohen Y, Batra AS, et al. Recommendations for advanced fellowship training in clinical pediatric and congenital electrophysiology: a report from the Training and Credentialing Committee of the Pediatric and Congenital Electrophysiology Society. Heart Rhythm. 2013;10:775–81.

**KEY WORDS** SPCTPD/ACC/AAP/AHA Training Statement, cardiac arrhythmias, clinical competence, electrocardiography, electrophysiology, fellowship training, implantable defibrillators, pacemakers, pediatric cardiology, pharmacology

## APPENDIX 1. AUTHOR RELATIONSHIPS WITH INDUSTRY AND OTHER ENTITIES (RELEVANT)—TASK FORCE 4: PEDIATRIC CARDIOLOGY FELLOWSHIP TRAINING IN ELECTROPHYSIOLOGY

| Committee Member | Employment | Consultant | Speakers Bureau | Ownership/ Partnership/ Principal | Personal Research | Institutional/ Organizational or Other Financial Benefit | Expert Witness |
|---|---|---|---|---|---|---|---|
| Anne M. Dubin *(Co-Chair)* | Stanford University—Professor, Pediatrics; Lucile Packard Children's Hospital, Stanford—Director, Pediatric Arrhythmia Service | None | None | None | None | None | None |
| Edward P. Walsh *(Co-Chair)* | Harvard Medical School—Professor of Pediatrics; Boston Children's Hospital—Chief, Cardiac Electrophysiology Division | None | None | None | None | None | None |
| Wayne Franklin | SafeCG—President/ Chief Executive Officer | None | None | None | None | None | None |
| Ronald J. Kanter | Miami Children's Hospital—Director, Electrophysiology; Duke University—Professor Emeritus | None | None | None | None | None | None |
| J. Philip Saul | Ohio State University—Professor and Chair, Department of Pediatrics; Associate Dean, Pediatric and Transitional Health; Nationwide Children's Hospital | None | None | None | None | None | None |
| Maully J. Shah | University of Pennsylvania Perelman School of Medicine—Associate Professor, Pediatrics; The Children's Hospital of Philadelphia—Director, Cardiac Electrophysiology | None | None | None | None | None | None |
| George F. Van Hare | Washington University School of Medicine—Louis Larrick Ward Professor of Pediatrics; Saint Louis Children's Hospital—Director of Pediatric Cardiology | None | None | None | None | None | None |
| Julie A. Vincent | Columbia University, College of Physicians and Surgeons—Division Chief, Pediatric Cardiology; Welton M Gersony Associate Professor of Pediatric Cardiology; Associate Professor of Pediatrics at CUMC; New York-Presbyterian Hospital—Director, Pediatric Interventional Cardiology | None | None | None | None | None | None |

For the purpose of developing a general cardiology training statement, the American College of Cardiology (ACC) determined that no relationships with industry (RWI) or other entities were relevant. This table reflects authors' employment and reporting categories. To ensure complete transparency, authors' comprehensive healthcare-related disclosure information—including RWI not pertinent to this document—is available in an online data supplement. Please refer to http://www.acc.org/guidelines/about-guidelines-and-clinical-documents/relationships-with-industry-policy for definitions of disclosure categories, relevance, or additional information about the ACC Disclosure Policy for Writing Committees.

## APPENDIX 2. PEER REVIEWER RELATIONSHIPS WITH INDUSTRY AND OTHER ENTITIES (RELEVANT)—TASK FORCE 4: PEDIATRIC CARDIOLOGY FELLOWSHIP TRAINING IN ELECTROPHYSIOLOGY

| Name | Employment | Representation | Consultant | Speakers Bureau | Ownership/ Partnership/ Principal | Personal Research | Institutional/ Organizational or Other Financial Benefit | Expert Witness |
|---|---|---|---|---|---|---|---|---|
| Dianne Atkins | University of Iowa—Division of Pediatric Cardiology | AHA | None | None | None | None | None | None |
| Lee Beerman | Children's Hospital of Pittsburgh—Associate Professor, Pediatrics, Cardiology Division | AHA | None | None | None | None | None | None |
| Regina Lantin-Hermoso | Texas Children's Hospital | ACC ACPC Council | None | None | None | None | None | None |
| Carole Warnes | Mayo Clinic—Professor, Medicine | ACC BOT | None | None | None | None | None | None |
| Eric Williams | Indiana University School of Medicine—Professor (Cardiology) and Associate Dean; Indiana University Health, Cardiology Service Line Leader | ACC CMC Lead Reviewer | None | None | None | None | None | None |

For the purpose of developing a general cardiology training statement, the ACC determined that no relationships with industry or other entities were relevant. This table reflects peer reviewers' employment, representation in the review process, as well as reporting categories. Names are listed in alphabetical order within each category of review. Please refer to http://www.acc.org/guidelines/about-guidelines-and-clinical-documents/relationships-with-industry-policy for definitions of disclosure categories, relevance, or additional information about the ACC Disclosure Policy for Writing Committees.

ACC indicates American College of Cardiology; ACPC, Adult Congenital and Pediatric Cardiology; AHA, American Heart Association; BOT, Board of Trustees; and CMC, Competency Management Committee.

JOURNAL OF THE AMERICAN COLLEGE OF CARDIOLOGY
© 2015 BY THE SOCIETY OF PEDIATRIC CARDIOLOGY TRAINING PROGRAM DIRECTORS, AMERICAN COLLEGE OF CARDIOLOGY FOUNDATION, AMERICAN ACADEMY OF PEDIATRICS, AND THE AMERICAN HEART ASSOCIATION, INC.
PUBLISHED BY ELSEVIER INC.

VOL. 66, NO. 6, 2015
ISSN 0735-1097/$36.00
http://dx.doi.org/10.1016/j.jacc.2015.03.008

TRAINING STATEMENT

# Task Force 5: Pediatric Cardiology Fellowship Training in Critical Care Cardiology

*Endorsed by the Pediatric Cardiac Intensive Care Society*

Timothy F. Feltes, MD, FAAP, FACC, FAHA, *Co-Chair*
Stephen J. Roth, MD, MPH, FAAP, *Co-Chair*
Melvin C. Almodovar, MD
Dean B. Andropoulos, MD, FAAP
Desmond J. Bohn, MB, BCH, FFARCS, MRCP, FRCPC
John M. Costello, MD, MPH, FAAP
Robert J. Gajarski, MD, MHSA, FAAP, FACC
Antonio R. Mott, MD
Peter Koenig, MD, FACC, FASE

## 1. INTRODUCTION

### 1.1. Document Development Process

The Society of Pediatric Cardiology Training Program Directors (SPCTPD) board assembled a Steering Committee that nominated 2 chairs, 1 SPCTPD Steering Committee member, and 6 additional members from a wide range of program sizes, geographic regions, and subspecialty focuses. Membership of this writing group reflected the diverse backgrounds of the physicians who currently direct pediatric cardiac critical care management, including pediatric cardiology, critical care medicine, and anesthesiology. Representatives from the American College of Cardiology (ACC), American Academy of Pediatrics (AAP), and American Heart Association (AHA) participated. The Steering Committee member was added to provide perspective to each Task Force as a "nonexpert" in that field. Relationships with industry and other entities were not deemed relevant to the creation of a general cardiology training statement; however, employment and affiliation information for authors and peer reviewers are provided in Appendixes 1 and 2, respectively, along with disclosure reporting categories. Comprehensive disclosure information for all authors, including relationships with industry and other entities, is available as an online supplement to this document.

The writing committee developed the document, approved it for review by individuals selected by the participating organizations (Appendix 2), and addressed their comments. The final document was approved by the SPCTPD, AAP, and AHA in February 2015 and approved by the ACC, as well as endorsed by the Pediatric Cardiac Intensive Care Society, in March 2015. This document is considered current until the SPCTPD revises or withdraws it.

### 1.2. Background and Scope

To achieve the best clinical outcomes and provide a safe care environment, every pediatric cardiologist should have basic patient assessment and stabilization skills, command a clear understanding of complex cardiovascular anatomy and physiology, know the effects of pharmacological agents on cardiac physiology, and function as an effective communicator within a multidisciplinary team (MDT). The experience garnered by a pediatric cardiology trainee in the pediatric cardiac intensive care unit (CICU)

The American College of Cardiology requests that this document be cited as follows: Feltes TF, Roth SJ, Almodovar MC, Andropoulos DB, Bohn DJ, Costello JM, Gajarski RJ, Mott AR, Koenig P. Task force 5: pediatric cardiology fellowship training in critical care cardiology. J Am Coll Cardiol 2015;66:712-22.

This article is copublished in *Circulation*.

concentrates the educational opportunity to refine these skill sets and is an important part of cardiology fellowship training.

The mission of this writing group was to build upon the pediatric cardiac critical care training guidelines published in 2005 (1). We retained and added to the General Training Goals identified by the 2005 task force (Sections 3.2.1 to 3.2.6) and have added to some of the Specific Training Goals (Sections 3.3.1 to 3.3.7) as well. We have added expected proficiencies to the 2005 guidelines, and where appropriate, included descriptive text to address these competencies. Our revised training recommendations describe the program resources and environment that are required for training pediatric cardiology fellows, together with a competency-based system promulgated by the American College of Graduate Medical Education (ACGME), to implement specific goals and objectives for training pediatric cardiology fellows. This system categorizes competencies into 6 core competency domains: Medical Knowledge, Patient Care and Procedural Skills, Systems-Based Practice, Practice-Based Learning and Improvement, Professionalism, and Interpersonal and Communication Skills, along with identification of suggested evaluation tools for each domain. Competencies unique to pediatric cardiac critical care are listed in Sections 3 and 4 (see the "2015 SPCTPD/ACC/AAP/AHA Training Guidelines for Pediatric Cardiology Fellowship Programs [Revision of the 2005 Training Guidelines for Pediatric Cardiology Fellowship Programs]: Introduction" for additional competencies that apply to all Task Force reports). Advanced competencies unique to pediatric cardiac critical care are listed in Section 4. Other publications address more comprehensive aspects of critical care knowledge that the pediatric cardiology trainee should attain (2).

### 1.3. Levels of Training—Core and Advanced

In this statement, we discuss core training for all fellows enrolled in a traditional 3-year pediatric cardiology fellowship and advanced training for fellows who wish to embark on a career in critical cardiac care. Core training is required for all trainees and is intended to ensure that fellows acquire the knowledge base and skills necessary to become a pediatric cardiologist referring his/her patient to the intensive care unit (ICU) and serve as a consultant or co-manager (not independent) of the patient. Advanced training guidelines are recommended for practitioners who are board-eligible/board-certified in pediatric cardiology and intend to manage patients as the primary cardiac intensivist in a pediatric ICU. These guidelines do not address training for practitioners with primary fellowship training other than pediatric cardiology.

## 2. PROGRAM RESOURCES AND ENVIRONMENT

Physical and/or administrative standalone pediatric CICUs are currently not a requirement in pediatric cardiology fellowship programs, although the trend is certainly toward that model. The cardiology trainee should attain the specified requirements outlined in these guidelines through interaction with pediatric cardiologists, pediatric intensivists, neonatologists, pediatric cardiac surgeons, and other practitioners. Cardiology program directors should have significant input related to the cardiac critical care experience of trainees to ensure the following proficiencies are obtainable. Pediatric cardiology fellows should receive the appropriate supervision by faculty well-versed in cardiac critical care.

## 3. CORE TRAINING: GOALS AND METHODS

### 3.1. Length of Training

The committee's recommendations on length of training are based on 2 primary goals: 1) those supervising trainees in the ICU environment require adequate exposure over time to evaluate trainee progress; and 2) every trainee needs to develop the competencies required to consult on patients in the ICU setting by the completion of fellowship training. In training programs where pediatric cardiology fellows act as the first-line (primary) medical provider for cardiac patients in the ICU (generally programs that have a separate CICU), a *minimum* of 2 months of full-time supervised experience in the ICU is recommended over the course of the 3-year fellowship. For programs where pediatric cardiology fellows function more as a consultant for cardiac patients in the ICU setting, at least 4 months of supervised experience providing such consultation is recommended over the course of the 3-year fellowship. Although the above represents the minimal training, the committee advocates strongly that cardiology fellows gain experience as a primary care provider for 3 to 6 months in a CICU setting over the course of the general cardiology fellowship. It is also important to note that these defined experiences require evaluation and management of neonates and pediatric patients with and/or being evaluated for cardiac disease. Therefore, fellowship directors must be cognizant that trainees gain experience in a neonatal and pediatric intensive care setting during fellowship training as part of their routine night/weekend inpatient call responsibilities. Trainees should be evaluated by the appropriate supervising faculty. The pediatric cardiology fellowship director should work closely with those supervisory physicians to create clear goals and measures of cognitive and technical competence and to provide a mechanism for timely evaluation of trainees.

**TABLE 1 Core Curricular Competencies and Evaluation Tools for Pediatric Cardiac Critical Care**

**Medical Knowledge**
- Know what medical and surgical treatments are appropriate for the underlying cardiac condition and the outcomes of these therapies.
- Know indications for, and limitations and risks of, invasive tests and procedures in critically ill patients.
- Know the interaction between the cardiac disease and other organ systems (see Section 3.3.1).
- Know the age-related differences in morbidity.
- Know the complex physiology of heart disease (see Section 3.3.2).
- Know the principles of pharmacology and relationship with cardiovascular physiology (see Section 3.3.3).
- Know the relationship between cardiac structure, function, and hemodynamic state.
- Know the means of, and indications for, mechanical circulatory support.

*Evaluation Tools: direct observation, conference participation and presentation, procedure logs, and in-training examination*

**Patient Care and Procedural Skills**
- Have the skills to evaluate and treat pediatric patients with congenital and acquired heart disease and assess acuity of illness (see Sections 3.2.1 and 3.2.2).
- Have the skills to triage patients through the levels of critical care from highest intensity to step-down care.
- Have the skills to create a patient care plan.
- Have the skills to provide resuscitative and stabilizing medical care (see Section 3.3.4).
- Have the skills to provide care or consultation to those managing patients with cardiac disease who have illnesses of noncardiac origin (see Section 3.2.3).
- Have the skills to provide consultation to those caring for postoperative cardiac patients (see Section 3.2.4).
- Have the skills to recognize complications of surgical procedures and plan investigation and recommend interventions when appropriate.
- Have the skills to diagnose and treat arrhythmias encountered in the ICU setting (see Section 3.3.5).
- Have the skills in airway management to assess airway adequacy and treat airway insufficiency, including mechanical ventilation, or consult experts to do so (see Section 3.3.6).
- Have the skills to provide cardiopulmonary support and resuscitation.

*Evaluation Tools: direct observation, multidisciplinary rounds participation, and procedure logs*

**Systems-Based Practice**
- Carry out high-quality, cost-effective, and safe patient care (see Section 3.2.6).
- Function as a member of a multidisciplinary team (see Section 3.2.5).

*Evaluation Tools: conference participation and presentation, direct observation, faculty evaluations, and 360 evaluations*

**Practice-Based Learning and Improvement**
- Identify knowledge and performance gaps and engage in opportunities to achieve focused education and performance improvement.
- Appropriately integrate new or emerging medical evidence.

*Evaluation Tools: multisource evaluation and reflection and self-assessment*

**Professionalism**
- Conduct oneself in a respectful and collegial manner.

*Evaluation Tools: conference participation and presentation, direct observation, faculty evaluation, 360 evaluation, and reflection and self-assessment*

**Interpersonal and Communication Skills**
- Effectively communicate with multiple teams involved in complex patient care.
- Provide nonbiased information to the patient/family.
- Communicate with the primary care and/or referring physicians.
- Practice effective handover of care between services.

*Evaluation Tools: direct observation, faculty evaluations, and 360 evaluations*

ICU indicates intensive care unit.

### 3.2. General Competencies

Through training and upon completion of a fellowship, the pediatric cardiology trainee is expected to demonstrate incremental proficiency in the skill sets delineated in Table 1. First is a proficiency in **diagnostic skills**. The pediatric cardiologist in the pediatric CICU should be able to diagnose congenital and acquired heart disease accurately and assess severity and acuity using physical examination and conventional, noninvasive methods. This includes the ability to perform an accurate and comprehensive cardiovascular examination, interpret the physical examination findings, assess the patient's history and laboratory data, and determine whether there are any inconsistencies in the patient's presentation and ongoing disease process. The trainee should demonstrate a proficiency in identifying physical and diagnostic indicators of patient deterioration (e.g., recognition of a low cardiac output state) and be capable of intervening appropriately.

Second, the trainee would be expected to demonstrate the **ability to create a patient care plan**. The pediatric cardiologist should be able to determine the appropriate use (or make recommendations to do so) of diagnostic testing, medical treatments, and interventional procedures for the care of the patient with congenital or acquired heart disease in the ICU setting. Such a care plan should be efficient, cost effective, and as safe as possible for the patient. The cardiology trainee should be able to construct an effective care plan and execute (or recommend) that plan, including appropriate communication with multiple teams (e.g., echocardiography, interventional catheterization, and surgical teams). He/she should provide ongoing input regarding physical examination, laboratory, and diagnostic study interpretation at the request of the managing clinical service(s).

Additional information on general competencies is included in the following text.

#### 3.2.1. Evaluate and Treat Neonates, Infants, and Older Pediatric Patients With Critical Structural Cardiac Disease

The cardiology trainee is expected to be proficient in the following:

- Skill to establish an accurate anatomic diagnosis and ascertain the relevant cardiopulmonary physiology compared to normal physiology across all pediatric ages.
- Knowing how to triage patients and which patients require ICU observation for potential risk of decompensation or to meet immediate medical needs.
- Providing appropriate medical therapy to stabilize the patient (provide for adequate oxygen delivery and organ perfusion).
- Knowing the indications for and limitations and risks of invasive testing and procedures, including issues related to sedation, anesthesia, and intrahospital transport of the critically ill patient with cardiac disease.
- Knowing what medical and surgical treatments are appropriate for the cardiac condition, and the short- and long-term outcomes of these therapies.
- Recognizing patients who are deviating from the usual postoperative course after commonly performed cardiac operations. Specifically, the trainee should be able to recognize patients who have a residual cardiac lesion, either due to an imperfect operation or incomplete preoperative diagnosis, and plan appropriate anatomic investigation and determine the need to recommend surgical or transcatheter intervention when clinically indicated (3).

In particular, the trainee should have sufficient training and experience to be effective in managing these types of patients:

- Neonates and young infants with ductal-dependent right heart obstructive lesions (e.g., tetralogy of Fallot with severe pulmonary stenosis, pulmonary valve atresia)
- Neonates with complex physiology such as obstructive left heart lesions (e.g., hypoplastic left heart syndrome, critical aortic stenosis), severe Ebstein's anomaly, and pulmonary atresia with ventricular septal defect and major aortopulmonary collateral vessels
- Neonates with d-transposition of the great arteries
- Neonates with total anomalous pulmonary venous connection with obstruction
- Infants with anomalous origin of a coronary artery from the pulmonary artery
- Single-ventricle patients with staged palliation (including cavopulmonary connection and Fontan physiology)

#### 3.2.2. Evaluate and Treat Neonates, Infants, and Older Pediatric Patients With Other Forms of Critical Cardiac Disease

In particular, the trainee should have sufficient training and experience to be effective in evaluating and treating the following:

- Patients with primary myocardial dysfunction
- Patients with acutely compromised cardiopulmonary status due to viral myocarditis or decompensated, end-stage cardiomyopathy
- Patients with acutely symptomatic arrhythmias
- Patients with acutely compromised cardiopulmonary status that is due to infectious endocarditis/sepsis and inflammatory (noninfectious) endocarditis
- Patients with pericardial effusion and tamponade
- Patients having a hypercyanotic episode
- Pediatric patients of any age with elevated pulmonary vascular resistance, with or without a structural abnormality of the heart

#### 3.2.3. Provide Care Assistance or Consultation to Those Providing Primary Care for Cardiac Patients With Illnesses of Noncardiac Origin

An example of this is an infant with single-ventricle physiology who develops bowel obstruction requiring a treatment approach that is different than a patient with a normal heart. Similarly, a fellow should understand what risks are posed to the cardiac patient undergoing noncardiac surgery. The fellow should be capable of accurately relaying the cardiovascular physiological concerns for this patient to care providers such as neonatologists, anesthesiologists, and noncardiac surgeons. The cardiology trainee is expected to be proficient in addressing the cardiovascular concerns of cardiac patients with pediatricians and noncardiac consultants.

#### 3.2.4. Provide Consultation to 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 catheterizations, including a clear delineation of 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 pharmacological and other therapies for patients with single-ventricle physiology.
- Provide consultation regarding therapies for patients with high pulmonary vascular resistance and pulmonary hypertension.

#### 3.2.5. Function as a Member of a MDT Demonstrating Professionalism and Excellent Communication Skills

In the current era, the pediatric cardiologist is an important member of a MDT. Cardiology trainees should demonstrate competency in the following MDT skill sets:

- Provide nonbiased information to the patient/family regarding known causes of congenital heart disease, the genetic and developmental implications, and treatment options.
- Conduct himself/herself in a respectful and collegial manner in the CICU.
- Be able to put the entire clinical picture together for the family and the care team. He/She should be familiar with the short-, mid-, and long-term consequences of congenital heart disease, and be able to provide patients, their families, and other clinical team members with realistic expectations.
- Provide ongoing updates to the patient and/or family while a patient remains in the pediatric CICU (e.g., in group case management discussions) and serve as an advocate for patients and their families.
- Communicate with primary care and referring physicians in a manner that keeps these physicians engaged and part of the MDT.
- Understand the general principles for providing effective and compassionate end-of-life and palliative care.
- Interact effectively with subspecialty teams (e.g., heart failure, transplant, electrophysiology).

#### 3.2.6. Quality Improvement and Patient Safety

In the past 10 years, there has been increasing focus on quality improvement and patient safety initiatives in intensive care medicine. Cardiology trainees should demonstrate competency in the following quality improvement and patient safety skill sets:

- Understand the principles behind a quality improvement process and recognize and abide by the principles of safe care delivery in the hospital.
- Understand the elements of an effective handover of care between services.
- Be familiar with institutional quality goals such as compliance with hand hygiene practices, elimination of iatrogenic infections, and reduction of medication errors. Fellows should be aware of their influence on the accomplishment of these measures and be active participants in the institution's safe care delivery efforts.
- Know the common complications that occur in cardiac patients in the ICU and how they may be prevented and treated.

### 3.3. Specific Competencies

Cardiology trainees should demonstrate an incremental proficiency in each of the following specific areas.

#### 3.3.1. Multiorgan System Management

The pediatric cardiologist consulting in the pediatric CICU should have an appreciation and understanding of the integration of cardiac function with other organ systems. This appreciation goes beyond simple oxygen delivery and cardiac output physiology. The cardiologist is expected to understand the effects of cardiac performance on the function of the respiratory, renal, neurological, and hepatic/gastrointestinal systems. Cardiology fellows rotating in the CICU should achieve a moderate level of knowledge and proficiency in the management of noncardiac conditions, including acute and chronic respiratory failure, acute and chronic renal failure, hepatic dysfunction, neurological dysfunction (as a result of hemorrhage, stroke, or anoxia), endocrinopathies, nutritional insufficiency, sepsis, hematologic abnormalities, and dependence on sedative/analgesic medications. Fellows should have an understanding of the neurocognitive outcome of patients as it relates to surgical as well as preoperative and postoperative factors. They should also become familiar with comorbidities, some congenital and others developmental in nature, that are frequently seen in older adolescents and young adults. The cardiology trainee should show proficiency in:

- Understanding interactions between the major noncardiac organ systems (e.g., lungs, kidney, liver, brain) and the heart.
- Understanding age-specific vulnerability of organ system function (e.g., renal function in the adult congenital heart disease patient postangiography).
- Understanding the major medical concerns related to older adolescents and young adults.
- Understanding the implications of genetic conditions and syndromes and implication for care.

#### 3.3.2. Cardiopulmonary Physiology

The cardiology trainee should show competency in understanding complex physiology that relates to the determinants of, and means of influencing, systemic arterial oxygen saturation, oxygen delivery, cardiac output, myocardial work, and vascular resistance for patients with all forms of congenital lesions, cardiomyopathies, and heart transplantation but with particular emphasis on those with the following:

- Single-ventricle and mixing lesions
- Ductal-dependent left-sided obstructive lesion

- Fixed restriction of pulmonary blood flow and/or ductal-dependent pulmonary blood flow lesions
- d-Transposition of the great arteries
- Pulmonary and systemic ventricles stressed by abnormal preload or afterload
- Cavopulmonary connection physiology

#### 3.3.3. Pharmacology and Relationship to Cardiovascular Physiology

The trainee should show competency in understanding the actions, mechanisms of action, side effects, and clinical use of these pharmacological agents:

- Inotropic agents (e.g., digoxin, adrenergic agonists, phosphodiesterase inhibitors)
- Vasodilators/antihypertensive agents (e.g., alpha-adrenergic antagonists, angiotensin-converting enzyme inhibitors, calcium channel antagonists, beta-adrenergic antagonists, nitric oxide donors)
- Commonly used antiarrhythmic agents (e.g., digoxin, adenosine, esmolol/propranolol, procainamide, lidocaine, amiodarone)
- Pulmonary vasodilators (e.g., inhaled nitric oxide, prostacyclin, PDE5 inhibitors)
- Prostaglandin $E_1$
- Neuromuscular blocking agents (e.g., pancuronium, vecuronium, rocuronium, succinylcholine)
- Analgesics and sedatives (e.g., opiates, ketamine, benzodiazepines, dexmedetomidine)
- The cardiovascular effects, risks, and benefits of commonly-used general anesthetics
- Anticoagulants (unfractionated and low-molecular-weight heparin, warfarin) and antiplatelet agents (aspirin, clopidogrel)
- Diuretics (e.g., furosemide, chlorothiazide, bumetanide, metolazone)
- Gastroesophageal reflux prophylaxis
- Antibiotics
- Immunosuppressant medications

#### 3.3.4. The Relationship Between Cardiac Structure, Function, and Hemodynamic State

The graduating cardiology fellow should know and be proficient in delivering stabilization management of the patient with congenital heart disease in the following circumstances:

- Recognize the appropriate circumstances for intravascular volume resuscitation in the hypotensive patient.
- Understand indications for fluid restriction and removal.
- Determine the need for initiation of prostaglandin $E_1$ infusion for ductal-dependent lesions in the neonate.
- Deliver pediatric advanced life-support measures per established guidelines.
- Recognize the indications for and know how to perform a supervised pericardiocentesis in patients with pericardial tamponade.
- Be familiar with factors that predispose to common postoperative complications and the appropriate diagnostic techniques and therapies for these complications.
- Know the indications for vasoactive and inotropic support.
- Know indications for antiarrhythmic management.
- Know indications and technique for cardioversion, defibrillation, and temporary pacing.

#### 3.3.5. Diagnosis of and Therapy for Arrhythmias

Although a minority of patients admitted to the pediatric CICU develop hemodynamically significant arrhythmias, these can be associated with cardiovascular compromise, and if incessant under specific conditions, even death. Fellows should be able to recognize the more common rhythm abnormalities in the ICU setting, especially those occurring in postoperative patients, such as the types of atrioventricular block, accessory pathway-mediated supraventricular tachycardia, atrial flutter, ectopic atrial tachycardia, junctional ectopic tachycardia, and ventricular tachycardia, and identify when they are causing hemodynamic compromise. Fellows should also learn the circumstances in which it is appropriate for them to consult a pediatric electrophysiologist for assistance with either diagnosis or management of more complex or refractory arrhythmias. For a more detailed discussion of the competencies required in electrophysiology, the reader is referred to Task Force 4: Pediatric Cardiology Fellowship Training in Electrophysiology.

#### 3.3.6. Airway Management

Pediatric cardiology fellows have widely varying experiences with airway management depending upon the role they have in caring for critically ill cardiac patients. Fellows training in programs that lack a pediatric CICU are typically in a consultant role, and they often obtain limited hands-on experience with both airway and mechanical ventilator management. By contrast, those who train in institutions that have a pediatric CICU and work in a primary provider role on the team usually gain more practical experience. In either training setting, fellows should acquire a basic understanding of airway and respiratory management and appreciate cardiopulmonary interactions (4). Cardiology trainees should demonstrate competency in or an understanding of the following:

- How to perform a thorough patient examination and interpret laboratory tests to assess the pulmonary system, including chest radiographs and blood gases.
- How to distinguish between respiratory insufficiency and cardiac decompensation.

- In patients with evolving respiratory insufficiency or failure, understand the indications for both noninvasive and invasive (tracheal intubation) airway support.
- How to bag-mask ventilate patients (adequate gas exchange can be maintained in many decompensating patients with this technique until tracheal intubation is performed).
- Commonly used modes of respiratory support and mechanical ventilation and their applications in patients with heart disease.
- Commonly-used agents for sedation, analgesia, and muscle relaxation for controlled tracheal intubation and positive pressure ventilation, including their cardiovascular effects.
- The effects of airway support on cardiac function and pulmonary vascular resistance.

#### 3.3.7. Cardiopulmonary Support, Including Cardiopulmonary Resuscitation and Mechanical Circulatory Support

Cardiology trainees should have basic skills in the ability to conduct cardiopulmonary resuscitation per established guidelines. Pediatric cardiology fellows should acquire the following:

- Pediatric Advanced Life Support (PALS) certification (or accepted alternative training, e.g., Fundamental Critical Care Support sponsored by the Society of Critical Care Medicine).

**TABLE 2 Curricular Competencies for Advanced Training in the Cardiac Intensive Care Unit**

**Medical Knowledge**
- Know the indications for utilization of standard and advanced modes of mechanical ventilation.
- Know the factors that affect venous return (i.e., airway pressure) and the impact of inspired oxygen on pulmonary vascular resistance, arterial oxygen saturation, and systemic perfusion.
- Know the upper airway anatomy and genetic/dysmorphic syndromes or acquired conditions that predispose to difficult tracheal intubation or bag-mask ventilation.
- Know the difficult airway management techniques such as laryngeal mask airway, fiberoptic laryngoscopy, video laryngoscopy, and emergency cricothyrotomy/tracheostomy.
- Know the indications for using various forms of mechanical circulatory support, including cardiac or VA ECMO and VADs.*
- Know advanced pharmacological therapies (e.g., esmolol for treatment of hypertension, vasopressin for treatment of shock).
- Know the indications for invasive evaluation of complications (e.g., heart catheterization or bronchoscopy) and invasive therapy (e.g., additional cardiac surgery, interventional catheterization, and tracheostomy).
- Know the appropriate time to obtain clinical consultation and what services to request.

*Evaluation Tools: direct observation, conference participation and presentation, and in-training examination*

**Patient Care and Procedural Skills**
- Have the skills to optimize gas exchange for patients with congenital heart disease.
- Have the skills to manage pulmonary injury related to barotrauma, excessive volume, and high levels of inspired oxygen and minimize such injuries.
- Have the skills to plan for expert airway consultation (anesthesiology and/or otolaryngology).
- Have the skills to implement and manage various forms of mechanical support including cardiac or VA ECMO and VADs.*
- Have the skills to obtain intravascular venous access (e.g., subclavian vein and internal jugular venous cannulation and ultrasound-guided procedures) and arterial access, to insert thoracostomy tubes, and to insert needles and catheters into the pericardial space.
- Have the skills to utilize epicardial electrodes and transesophageal leads for diagnosis and treatment of rhythm abnormalities and use the entire spectrum of pharmacological agents for arrhythmias.
- Have the skills to manage pulmonary hypertension, including the use of oxygen, inhaled nitric oxide, inhaled prostacyclin derivatives, IV epoprostenol, oral bosentan, and IV/oral sildenafil.
- Have the skills to recognize complications such as residual cardiac lesions, acute coronary artery obstruction, paralyzed hemidiaphragm(s), paralyzed vocal cord(s), large airway obstruction from extrinsic compression, compartment syndrome following femoral arterial cannulation for cardiopulmonary bypass, and prolonged thoracostomy tube drainage.
- Have the skills to manage all noncardiac organ systems independently or in collaboration with appropriate consultants.
- Have the skills to manage the preoperative and postoperative OHT patient including acute or chronic allograft rejection.
- Have the skills to manage the patient with persistent renal failure including indications for renal replacement therapy.
- Have the skills to manage acute and chronic neurological dysfunction, including acute seizures, ischemic and hemorrhagic stroke, global hypoxic–ischemic brain injury, and increased intracranial pressure.
- Have the skills to manage nutritional support for ICU patients utilizing the most appropriate means.
- Have the skills to recognize and treat common transfusion-related complications.

*Evaluation Tools: direct observation, conference participation, and procedure logs*

**Systems-Based Practice**
- Lead the multidisciplinary team.
- Plan and manage patient transfer to/from other hospital units to/from the CICU, including medication reconciliation, effective handovers, and preparing and informing the patient and parents of the transfer.

*Evaluation Tools: conference participation and presentation, direct observation, faculty evaluation, and 360 evaluation*

**Professionalism**
- Supervise the scope of practice and responsibilities of each care provider in the pediatric CICU.
- Champion the safety and quality core values of the unit and hospital.
- Teach care team members (including nurses) based on their knowledge acquired throughout their primary fellowship and advanced training. (This may include development of an educational program or initiative to formalize the educational process for trainees.)

*Evaluation Tools: conference participation and presentation, direct observation, faculty evaluation, and 360 evaluation*

*Although not considered a mandatory rotation as part of advanced training in the CICU, the writing committee recognizes that time spent in an operating room setting working with cardiopulmonary perfusionists can significantly enhance the trainee's understanding of cardiopulmonary support and is strongly encouraged.

CICU indicates cardiac intensive care unit; ICU, intensive care unit; IV, intravenous; OHT, orthotopic heart transplant; VA EMCO, venoarterial extracorporeal membrane oxygenation; and VAD, ventricular assist device.

- Understanding of the specific clinical situations in which modifications of the PALS guidelines should be employed (e.g., avoidance of administration of high concentrations of supplemental $O_2$ to the preoperative newborn with hypoplastic left heart syndrome and underlying pulmonary overcirculation).
- Ability to provide initial stabilization of the hemodynamically compromised patient with congenital heart disease, including neonates and young infants.

Mechanical circulatory support of the failing myocardium has evolved from the predominant use of venoarterial extracorporeal membrane oxygenation (VA ECMO) to include ventricular assist devices (VADs) to support either the failing left ventricle (LVAD), right ventricle (RVAD), or both ventricles (BiVAD). These support techniques can be used to recover patients with congenital heart disease after cardiac surgery (typically VA ECMO), as a "bridge" to cardiac transplantation (typically VADs), or more recently, as "destination therapy" in patients who are determined not to be eligible for cardiac transplantation (5–7). Although not all pediatric cardiology fellowship training programs offer clinical exposure to advanced heart failure patients who are treated with mechanical support or cardiac transplantation, the trainee should be familiar with, and capable of, conversing about both mechanical circulatory support and cardiac transplantation. For a more detailed discussion of the competencies required in heart failure and transplantation, the reader is referred to Task Force 7: Pediatric Cardiology Fellowship Training in Pulmonary Hypertension, Advanced Heart Failure, and Transplantation.

## 4. ADVANCED TRAINING: GOALS AND METHODS

### 4.1. Requirements and Length of Training

If the pediatric cardiologist wishes to undertake primary responsibility for the comprehensive management of critically ill pediatric patients with congenital or acquired heart disease, then advanced training beyond a conventional pediatric cardiology fellowship is needed to acquire skills and knowledge to work, attend, and offer a higher level of consultation in the pediatric CICU environment. This may be in the form of a focused year in CICU fellowship training (i.e., a fourth-year pediatric CICU fellowship that is not certified training) or formal pediatric critical care medicine training that leads to board eligibility (currently a 2-year fellowship when combined with a 3-year pediatric cardiology fellowship). The recommendations in this section refer to the fourth-year CICU fellowship only. This advanced training should include a minimum of 9 months of added clinical training at an institution in which at least 250 pediatric cardiac surgeries per year are performed using cardiopulmonary bypass in addition to electives and/or research to complete the 12-month training. This number of 250/year is by consensus of the authors of the 2005 and these 2015 guidelines (1). Included within this target number should be approximately 35 neonatal (age <28 days) cardiac surgeries that utilize cardiopulmonary bypass. The advanced training should also be conducted at a center that provides mechanical circulatory support and pediatric heart transplantation. Trainees are advised to work closely with attending physicians who have completed specialized critical care training to learn the pros and cons for both routes of training and to determine what best fits their career goals.

Advanced training in pediatric cardiac intensive care is intended to prepare physicians who will undertake primary responsibility for the comprehensive management of critically ill patients with congenital or acquired heart disease in the ICU setting. Because this subspecialty is at the crossroads of pediatric cardiology, pediatric critical care medicine (PCCM), and pediatric cardiac anesthesiology, many physicians with primary training in fields other than pediatric cardiology work in this area. The remainder of 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., PCCM or pediatric cardiac anesthesiology). The committee believes, however, that all such physicians should have at a minimum PALS certification and consider Advance Cardiac Life Support (ACLS) training and certification, given the growing population of adult congenital heart patients cared for in pediatric CICUs.

### 4.2. Specific Competencies

In addition to the skill set outlined in the previous text for core training, the pediatric cardiologist serving as the attending physician in the pediatric CICU should be proficient in additional specific skills as outlined in **Table 2**.

## 5. EVALUATION AND DOCUMENTATION OF COMPETENCE

All training programs should include written goals and objectives for each cardiac critical care rotation, with performance goals set according to the fellow's level of training. These will serve as the basis for formative feedback. A copy of these goals and objectives should be supplied and explained to the trainee at the onset of fellowship training and reviewed at the beginning of each rotation. Evaluation of fellows should be performed midway through, and at the completion of, each rotation; evaluations should be directed toward whether the

fellow met those prespecified aims. The fellow evaluation should be performed by the cardiac critical care laboratory director and/or senior cardiac critical care physician chosen as director of cardiac critical care training. The fellow evaluation should assess the fellow's performance in each of the 6 areas of core competencies, as appropriate for the level of training, and should be based on direct observation of the fellow. Evaluation of competency in preparation, performance, and interpretation of the results of a procedure should be given more consideration than a focus on the number of procedures performed. Evaluation of competency should be done in person with the trainee and documented in his or her fellowship record. If the trainee is not progressing as expected, remedial actions should be arranged and documented in accordance with institutional procedures. All fellows should maintain a log (preferably electronic) of all procedures performed.

## REFERENCES

**1.** Kulik T, Giglia TM, Kocis KC, et al. ACCF/AHA/AAP recommendations for training in pediatric cardiology. Task force 5: requirements for pediatric cardiac critical care. J Am Coll Cardiol. 2005;46:1396–9.

**2.** Andropoulos D, Chang A. Pediatric cardiovascular intensive care. In: Allen HD, Driscoll D, Shaddy R, Feltes T, editors. Moss and Adams' Heart Disease in Infants, Children, and Adolescents. Philadelphia, PA: Lippincott Williams & Wilkins, 2013:483–529.

**3.** Mazwi ML, Brown DW, Marshall AC, et al. Unplanned reinterventions are associated with postoperative mortality in neonates with critical congenital heart disease. J Thorac Cardiovasc Surg. 2013;145:671–7.

**4.** Bronicki RA, Anas NG. Cardiopulmonary interaction. Pediatr Crit Care Med. 2009;10:313–22.

**5.** Salvin JW, Laussen PC, Thiagarajan RR. Extracorporeal membrane oxygenation for postcardiotomy mechanical cardiovascular support in children with congenital heart disease. Paediatr Anaesth. 2008;18:1157–62.

**6.** Almond CS, Singh TP, Gauvreau K, et al. Extracorporeal membrane oxygenation for bridge to heart transplantation among children in the United States: analysis of data from the Organ Procurement and Transplant Network and Extracorporeal Life Support Organization Registry. Circulation. 2011;123:2975–84.

**7.** Fraser CD Jr., Jaquiss RD, Rosenthal DN, et al. Prospective trial of a pediatric ventricular assist device. N Engl J Med. 2012;367:532–41.

**KEY WORDS** SPCTPD/ACC/AAP/AHA Training Statement, clinical competence, critical care cardiology, fellowship training, mechanical circulatory support, pediatric cardiology

## APPENDIX 1. AUTHOR RELATIONSHIPS WITH INDUSTRY AND OTHER ENTITIES (RELEVANT)—TASK FORCE 5: PEDIATRIC CARDIOLOGY FELLOWSHIP TRAINING IN CRITICAL CARE CARDIOLOGY

| Committee Member | Employment | Consultant | Speakers Bureau | Ownership/ Partnership/ Principal | Personal Research | Institutional/ Organizational or Other Financial Benefit | Expert Witness |
|---|---|---|---|---|---|---|---|
| Timothy F. Feltes *(Co-Chair)* | Nationwide Children's Hospital, The Ohio State University—Chief, Pediatric Cardiology; Professor of Pediatrics | None | None | None | None | None | None |
| Stephen J. Roth *(Co-Chair)* | Lucile Packard Children's Hospital Stanford—Chief, Division of Pediatric Cardiology; Director, Children's Heart Center; Stanford University School of Medicine—Professor of Pediatrics (Cardiology) | None | None | None | None | None | None |
| Melvin C. Almodovar | Boston Children's Hospital—Medical Director, Cardiac Intensive Care Unit, Department of Cardiology; Harvard Medical School—Assistant Professor of Pediatrics | None | None | None | None | None | None |
| Dean B. Andropoulos | Texas Children's Hospital—Anesthesiologist-in-Chief; Baylor College of Medicine—Professor, Anesthesiology and Pediatrics; Vice Chair for Clinical Affairs, Department of Anesthesiology | None | None | None | None | None | None |
| Desmond J. Bohn | CritiCall Ontario—Provincial Medical Director | None | None | None | None | None | None |
| John M. Costello | Ann & Robert H. Lurie Children's Hospital of Chicago—Director, Inpatient Cardiology; Medical Director, Regenstein Cardiac Care Unit; Northwestern University Feinberg School of Medicine—Associate Professor of Pediatrics | None | None | None | None | None | None |
| Robert J. Gajarski | C.S. Mott Children's Hospital, University of Michigan—Professor, Pediatrics; Director, Cardiac ICU | None | None | None | None | None | None |
| Antonio R. Mott | Texas Children's Hospital—Medical Director, Inpatient Cardiology Service; Baylor College of Medicine—Associate Professor of Pediatrics | None | None | None | None | None | None |
| Peter Koenig | Ann & Robert H. Lurie Children's Hospital of Chicago—Pediatric Cardiology Fellowship Director; Northwestern University Feinberg School of Medicine—Associate Professor of Pediatrics | None | None | None | None | None | None |

For the purpose of developing a general cardiology training statement, the American College of Cardiology (ACC) determined that no relationships with industry (RWI) or other entities were relevant. This table reflects authors' employment and reporting categories. To ensure complete transparency, authors' comprehensive healthcare-related disclosure information—including RWI not pertinent to this document—is available in an online data supplement. Please refer to http://www.acc.org/guidelines/about-guidelines-and-clinical-documents/relationships-with-industry-policy for definitions of disclosure categories, relevance, or additional information about the ACC Disclosure Policy for Writing Committees.

## APPENDIX 2. PEER REVIEWER RELATIONSHIPS WITH INDUSTRY AND OTHER ENTITIES (RELEVANT)—TASK FORCE 5: PEDIATRIC CARDIOLOGY FELLOWSHIP TRAINING IN CRITICAL CARE CARDIOLOGY

| Name | Employment | Representation | Consultant | Speakers Bureau | Ownership/ Partnership/ Principal | Personal Research | Institutional/ Organizational or Other Financial Benefit | Expert Witness |
|---|---|---|---|---|---|---|---|---|
| Seema Mital | Hospital for Sick Children—Pediatric Cardiology | AHA | None | None | None | None | None | None |
| Carole Warnes | Mayo Clinic—Professor, Medicine | ACC BOT | None | None | None | None | None | None |
| Eric Williams | Indiana University School of Medicine—Professor (Cardiology) and Associate Dean; Indiana University Health, Cardiology Service Line Leader | ACC CMC Lead Reviewer | None | None | None | None | None | None |
| Regina Lantin-Hermoso | Texas Children's Hospital | ACPC Council | None | None | None | None | None | None |

For the purpose of developing a general cardiology training statement, the ACC determined that no relationships with industry or other entities were relevant. This table reflects peer reviewers' employment, representation in the review process, as well as reporting categories. Names are listed in alphabetical order within each category of review. Please refer to http://www.acc.org/guidelines/about-guidelines-and-clinical-documents/relationships-with-industry-policy for definitions of disclosure categories, relevance, or additional information about the ACC Disclosure Policy for Writing Committees.

ACC indicates American College of Cardiology; ACPC, Adult Congenital and Pediatric Cardiology; AHA, American Heart Association; BOT, Board of Trustees; and CMC, Competency Management Committee.

JOURNAL OF THE AMERICAN COLLEGE OF CARDIOLOGY
VOL. 66, NO. 6, 2015

PUBLISHED BY ELSEVIER INC.
ISSN 0735-1097/$36.00
http://dx.doi.org/10.1016/j.jacc.2015.03.011

TRAINING STATEMENT

# Task Force 6: Pediatric Cardiology Fellowship Training in Adult Congenital Heart Disease

Karen Stout, MD, FACC, *Co-Chair*
Anne Marie Valente, MD, FACC, *Co-Chair*
Peter J. Bartz, MD, FASE
Stephen Cook, MD, FACC
Michelle Gurvitz, MD, MS, FACC
Arwa Saidi, MD, FACC
Robert D. Ross, MD, FAAP, FACC

## 1. INTRODUCTION

### 1.1. Document Development Process

The Society of Pediatric Cardiology Training Program Directors (SPCTPD) board assembled a Steering Committee that nominated 2 chairs, 1 SPCTPD Steering Committee member, and 4 additional experts from a wide range of program sizes, geographic regions, and subspecialty focuses. Representatives from the American College of Cardiology (ACC), American Academy of Pediatrics (AAP), and American Heart Association (AHA) participated. The Steering Committee member was added to provide perspective to each Task Force as a "nonexpert" in that field. Relationships with industry and other entities were not deemed relevant to the creation of a general cardiology training statement; however, employment and affiliation information for authors and peer reviewers are provided in Appendixes 1 and 2, respectively, along with disclosure reporting categories. Comprehensive disclosure information for all authors, including relationships with industry and other entities, is available as an online supplement to this document.

The writing committee developed the document, approved it for review by individuals selected by the participating organizations (Appendix 2), and addressed their comments. The final document was approved by the SPCTPD, AAP, and AHA in February 2015 and approved by the ACC in March 2015. This document is considered current until the SPCTPD revises or withdraws it.

### 1.2. Background and Scope

It is estimated that there are currently more adults than children with congenital heart disease (CHD). Despite this, most adult cardiologists are not familiar with CHD, and to date, pediatric cardiology training has not focused on typical adult diseases or on the social issues that impact adults. Pediatric cardiology training will provide a sound basis for the diagnosis and management of CHD that spans all ages; however, the manifestations, diagnosis, treatments, and outcomes of CHD in adults have important differences from those diseases in children.

The goal of Adult Congenital Heart Disease (ACHD) training for pediatric cardiology fellows is to expose them to the common sequelae of both repaired and unrepaired CHD in the adult. This presupposes that the trainee has a solid foundation in the principles of CHD diagnosis and management gained through his or her pediatric cardiology training. Additional subjects for trainees to learn should include the common medical conditions encountered in adults such as coronary disease, pregnancy, and depression. The impact of issues such as employment and insurability

The American College of Cardiology requests that this document be cited as follows: Stout K, Valente AM, Bartz PJ, Cook S, Gurvitz M, Saidi A, Ross RD. Task force 6: pediatric cardiology fellowship training in adult congenital heart disease. J Am Coll Cardiol 2015;66:723-31.

This article is copublished in *Circulation*.

should also be a part of the curriculum as they strongly impact patient well-being.

A smooth transition of patients from pediatric to adult care is the first step in ACHD care, and in most medical systems, that responsibility lies with the pediatric providers. Therefore, education on the transition process, awareness of the needs of ACHD patients, systems available for care of ACHD patients, and resources to ensure adequate cardiac care are all important parts of the pediatric cardiology curriculum in ACHD.

There are a variety of ways to fulfill the training goals in ACHD. The ideal experience combines didactic lectures and dedicated inpatient and outpatient ACHD clinical rotations. There is substantial variation between institutions in the care of ACHD patients, and pediatric cardiology fellowship training programs should avail themselves of dedicated ACHD-trained or experienced cardiologists and ACHD programs. For those fellows desiring to care for ACHD patients, additional subspecialty training is required that is more intensive and focused than the ACHD training in either pediatric or adult cardiology programs. What follows are descriptions of the different issues that should be addressed in core ACHD training for pediatric cardiology fellows. For those who desire to pursue a career as an ACHD specialist, 2 years of additional training will be needed to fulfill the requirements for the ACHD Board Certification examination.

Our revised training recommendations describe the program resources and environment that are required for training pediatric cardiology fellows, together with a competency-based system promulgated by the American College of Graduate Medical Education (ACGME), to implement specific goals and objectives for training pediatric cardiology fellows. This system categorizes competencies into 6 core competency domains: Medical Knowledge, Patient Care and Procedural Skills, Systems-Based Practice, Practice-Based Learning and Improvement, Professionalism, and Interpersonal and Communication Skills, along with identification of suggested evaluation tools for each domain. Core competencies unique to ACHD are covered in Section 3 (see the "2015 SPCTPD/ACC/AAP/AHA Training Guidelines for Pediatric Cardiology Fellowship Programs [Revision of the 2005 Training Guidelines for Pediatric Cardiology Fellowship Programs]: Introduction" for additional competencies that apply to all Task Force reports).

### 1.3. Levels of Expertise—Core and Advanced

In this statement, we discuss core training for all fellows enrolled in a traditional 3-year pediatric cardiology fellowship and advanced training for fellows who wish to embark on a career in ACHD. Core training is required for all trainees and is intended to ensure that fellows acquire the knowledge base and skills necessary to become a pediatric cardiologist referring his/her patient at an age appropriate for ACHD care. Advanced training guidelines are recommended for fellows who wish to specialize in ACHD following training. In December 2012, after a joint petition by the American Board of Pediatrics and American Board of Internal Medicine, ACHD was formally recognized by the American Board of Medical Specialties as a subspecialty of adult and pediatric cardiology. As such, advanced training is needed to qualify a fellow to sit for the ACHD Board examination and to be an ACHD cardiologist. Advanced ACHD training is for an additional 2 years after completion of either pediatric cardiology or adult cardiovascular disease training. The specifics of the ACHD training pathways are being developed and are part of the 2015 adult cardiology training guidelines (1).

## 2. PROGRAM RESOURCES AND ENVIRONMENT

Training in ACHD should be obtained in a center or centers where there is both a pediatric and an adult cardiology training program accredited by the ACGME. Ideally, the training center has available ACHD expertise from at least 1 trained or experienced ACHD cardiologist, multidisciplinary ACHD experience, and a dedicated ACHD program or clinic. This center should have clinical volumes sufficient to allow for exposure of each trainee to a wide spectrum of ACHD. If the training center lacks ACHD expertise, consideration for "away rotations" and electronic educational resources to ensure attainment of training requirements should be considered.

Pediatric cardiology trainees should be aware of the 2008 ACC/AHA guidelines (2) regarding care of patients in ACHD centers. This may involve routine primary cardiology care at the ACHD center or shared care with a local referring cardiologist. The type and location of care recommended depends on the severity and complexity of the underlying condition. The 32nd Bethesda conference (3) outlines the components of a comprehensive regional ACHD referral center. It is recommended that non-ACHD adult or pediatric cardiologists caring for adults develop a referral relationship with an established center.

At a core competency level, there are several mechanisms that would fulfill the training goals in ACHD. The exposure to dedicated ACHD care should occur early within the pediatric cardiology fellowship, ideally within the first year of training. For many programs, a dedicated 1-month rotation with an established ACHD program is preferred. The rotation would allow a spectrum of exposure to ACHD patients, including outpatient clinic, inpatient consults, imaging, and exposure to the array of issues ACHD patients may face, including CHD-related cardiac issues, non-CHD cardiac issues (i.e., coronary disease), cardiac and noncardiac surgery, heart failure, pulmonary hypertension, and obstetrics. If there are no

dedicated local ACHD programs, then local hospital-based graduate medical education (GME) should provide support for an away elective. With over 100 established ACHD programs throughout the country, most pediatric cardiology fellowship programs are in coordination with an ACHD program or a program exists within close proximity. However, if there are no local ACHD programs or an away-elective is not feasible for various reasons, online modules should be utilized as part of the requirements for pediatric cardiology fellows. Many sources exist for this information, and program directors must be familiar with the various online learning opportunities to create the best possible learning experience for their pediatric cardiology trainees if a dedicated ACHD rotation is not feasible.

Trainees should be familiar with the multiple environments in which ACHD patients are followed for both inpatient care (adult hospitals, children's hospitals, and combined hospitals) and outpatient care (pediatric cardiology, general adult cardiology, and ACHD cardiology). They should also recognize that many patients are "lost" or neglect follow-up and may be seen only in general practice environments such as family or internal medicine or may receive no medical care at all unless emergencies arise. It is common for ACHD patients to present to an emergency room with little knowledge of their heart condition, prior surgeries and interventions, or even their medications.

It is important for fellows to understand when to refer ACHD patients for noncongenital adult medical expertise (cardiac and noncardiac), including the fields of general internal medicine, obstetrics, gynecology, nephrology, hepatology, hematology, and psychiatry. Specific exposure to multidisciplinary teams caring for ACHD should be emphasized, including those outlined in **Table 1**.

Any diagnostic or interventional procedures for adults with moderate or complex CHD including (but not limited to) catheterization, surgery, echocardiography, or cardiac magnetic resonance imaging (MRI) should be performed in a location and by personnel with expertise in that modality and ACHD. For procedures requiring anesthesia, it is important to include cardiac anesthesiologists with experience with ACHD.

**TABLE 1 Multidisciplinary Teams Involved in ACHD Care**

- High-risk obstetrics
- Pulmonary hypertension
- Heart failure/transplant
- Genetics
- Neurology
- Nephrology
- Hematology
- Gastroenterology
- Cardiac pathology
- Rehabilitation services
- Social services
- Vocational services
- Financial counselors

Adapted from the 2008 ACC/AHA Guidelines for the Management of Adults With Congenital Heart Disease (2).

ACC indicates American College of Cardiology; ACHD, adult congenital heart disease; and AHA, American Heart Association.

## 3. CORE TRAINING: GOALS AND METHODS

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

### 3.1. Managing the Transition From Adolescence to Adulthood

Transitioning the care of the adolescent to adulthood should begin with encouraging greater patient involvement in their health care. Emphasis should be placed on uninterrupted health care that is patient centered, age and developmentally appropriate, flexible, and comprehensive. Age-appropriate education about medical conditions should promote skills in communication, decision making, self-care, and self-advocacy. This will promote greater personal and medical independence and a sense of control over healthcare decisions. The ultimate goal of a transition program is to optimize the quality of life, life expectancy, and future productivity of young patients (2). Specific teaching goals include learning:

- The concept of comprehensive care that is coordinated and managed through a medical home
- The need to educate adult providers in managing chronic conditions previously limited to the pediatric population
- The need for ongoing, coordinated communication between patients, families, and pediatric and adult healthcare providers to facilitate transition and transfer
- The timing for transition, which should be based on the patient's medical and development status and should be individualized to both the patient and family's needs
- The need to engage the adolescent in transition planning, raising awareness in the early teenage years
- The need for the pediatric cardiology provider to initiate and work together with the adolescent and family on a transition plan
- The importance of pediatric providers directing health discussions toward the adolescent in a way that is developmentally appropriate and sensitive to parental concerns

### 3.2. Recognition of Concomitant Adult Medical Conditions

Adults with CHD may develop comorbidities that can either complicate the management of CHD or worsen the outcomes of CHD. The care of adults with CHD requires familiarity with common adult medical conditions, both cardiac and noncardiac, and awareness of available guidelines to treat them. Important conditions include coronary artery disease, acute myocardial infarction, heart failure, hypertension, hyperlipidemia, atrial

fibrillation, stroke, diabetes mellitus, metabolic syndrome, sleep apnea, obstructive lung disease, obesity, lifestyle issues, including tobacco, alcohol, and drug use; exercise; and depression/anxiety.

Familiarity with the commonly used medical therapies for adult-acquired heart disease is needed, including statins, aspirin, beta blockers, angiotensin-converting enzyme inhibitors/angiotensin receptor blockers, aldosterone antagonists, and anticoagulants. Trainees must also learn the difference in accepted indications for pediatric and adult patients for these medications.

Pediatric cardiologists are not expected to manage uniquely adult cardiac or noncardiac conditions, but need to be aware of available resources for appropriate internist, cardiologist, or other subspecialty referrals.

### 3.3. Knowledge of Electrophysiology in ACHD Care

Arrhythmias are common in ACHD patients, and effective diagnosis and management requires understanding of the underlying anatomy, surgical repairs, and treatment options (4). Although there are many similarities in the diagnosis and management of arrhythmias in ACHD patients compared to pediatric patients, the presentation, complications, management options, and outcomes may be quite different. There are subgroups of ACHD in whom the risk for arrhythmias increases with age such as Mustard/Senning repairs of transposition of the great arteries (TGA) and atriopulmonary Fontan palliations. These patients are prone to both tachyarrhythmias and bradyarrhythmias; therefore, a thorough understanding of these operations is essential.

Anticoagulation for stroke prevention may differ in ACHD patients because of advancing age and comorbidities. Management may be helped by the ACC/AHA guidelines regarding stroke prevention in the presence of atrial arrhythmias (5).

### 3.4. Management of Advanced Heart Failure and Determination of Transplant Candidacy in ACHD Patients

As the population of adults with CHD continues to increase, so does the prevalence of heart failure. Pediatric cardiology fellowship training should include an understanding of the multiple factors that contribute to ventricular dysfunction in adults with CHD (6,7), including abnormal vascular function, particularly in those with Fontan physiology (8,9).

Training should emphasize ACHD patients who are at significant risk of heart failure, particularly those with systemic right ventricles, including Mustard/Senning repairs of TGA and congenitally corrected TGA, as well as patients with a single ventricle who have undergone a Fontan procedure (10). They should also understand the neurohormonal abnormalities that frequently accompany heart failure in these adults (11).

Each fellow should have an understanding of the currently available options for mechanical circulatory support (MCS) in adult congenital heart patients (12) and participate in multidisciplinary team discussions regarding optimal timing of referral of adults with CHD for MCS/transplant (13). Fellows should also understand the potential difficulties or contraindications of transplant in adults. This may range, for example, from issues of alloimmunization to technical limitations, pulmonary hypertension, and substance use.

### 3.5. Understanding the Unique Aspects of Caring for Cyanotic Adults With Eisenmenger Syndrome and Pulmonary Vascular Disease

A subset of ACHD patients live with cyanosis, either from unrepaired or palliated CHD or reversal of a left-to-right shunt due to Eisenmenger syndrome (ES). These adults may present with multisystem dysfunction from the secondary erythrocytosis that occurs as a result of their hypoxemia. Fellows need to recognize these complications, which include iron deficiency, gallstones, gout, and cerebral vascular accidents. They also should know the therapies to prevent these complications (e.g., avoidance of dehydration, iron replacement) (14). ACHD patients may also experience pulmonary vascular disease. In 1 large population-based study, the prevalence of pulmonary hypertension in ACHD patients was at least 6%, and those patients had a more than 2-fold higher risk of all-cause mortality and 3-fold higher risk of heart failure and arrhythmias compared to those without pulmonary hypertension (15). The trainee should be aware of recent investigations of advanced therapies for pulmonary vascular disease in ACHD patients that have offered promise for improved quality of life and survival (16). Despite guideline recommendations to treat adults with ES with pulmonary vasodilator therapy (Class IIa, *Level of Evidence: C*) (2), the majority of patients living with ES are not receiving advanced therapies (17).

### 3.6. Recognition of the Importance of Palliative Care

Although the prognosis for many adults with CHD is quite good with appropriate management, there are many patients who will die of their underlying CHD. For many patients with end-stage disease, there are surgical, medical, or advanced heart failure therapies such as ventricular assist devices or transplantation that can improve symptoms or longevity. However, many patients may not realistically benefit from further aggressive treatment or may choose not to continue therapy. If so, palliative care may be an appropriate option. The difficulty in providing accurate prognostic data for ACHD patients can make the optimal timing for palliative care referrals difficult. There are prognostic indicators in adults with heart failure as a result

of other causes that may also apply to ACHD patients, and fellows should be familiar with these resources.

### 3.7. Understanding Mental Health and Cognitive Outcomes

The trainees need to be aware of the potential for neurocognitive and psychological issues in ACHD patients. For example, there is at least a 3 times higher prevalence of psychiatric disorders, particularly depression and anxiety, among adults with neurocognitive delays (18). There is equivocal data on health-related quality of life in ACHD patients compared to the general population depending on the mode of evaluation. Some genetic syndromes, such as 22q11 deletion, include a component of developmental delay and the potential for adult-onset psychiatric disorders (19). At this time, screening for depression, anxiety, and other mood disorders is not in the ACHD guidelines, but it is recommended that ACHD care providers be aware of these issues and intervene or refer when appropriate.

It is also important for trainees to recognize the impact that neurocognitive delay and impaired social adjustments may have on future lifestyle issues in adulthood. This is particularly true for assuming independence, disease self-management, and employment. Appropriate counseling, particularly on employment options, should be considered.

### 3.8. Assess Safety of Participation in Sports and Exercise

The most common congenital or inherited heart conditions that have been associated with sudden death during sports and exercise participation are hypertrophic cardiomyopathy, coronary artery anomalies, Marfan syndrome, and aortic valve disease. Less common lesions with increased risks are complex defects, such as repaired transposition and single ventricle, and those with associated pulmonary vascular disease. In addition, sudden death may occur with arrhythmias induced by exercise from certain forms of congenital long QT syndrome. As adolescents and young adults enroll in progressively more demanding activities, comprehensive evaluation and counseling are essential. The goal should be to assess the safety of participation in sports and exercise to optimize quality of life and improve health. Trainees should be familiar with the appropriate diagnostic testing needed and the specific recommendations described within the 36th Bethesda Conference report (20). Equally important is providing support, alternatives, and counseling for those ACHD patients who are no longer able to participate in sports they may have enjoyed in the past because of the health risks they pose.

### 3.9. Recognition of Women's Reproductive Health: Contraception and Pregnancy

Over the course of training in pediatric cardiology, fellows must learn the hemodynamic changes that occur during pregnancy and the postpartum period. Each fellow should demonstrate knowledge of the pregnancy-related physiological changes in women with various types of CHD during pregnancy and their potential consequences on both the mother and fetus (21). They also need to know the established risk factors for pregnant women with CHD for both maternal cardiac and obstetrical complications (22–24), genetic risks of recurrence of CHD in the fetus, as well as late adverse cardiac outcomes (25). Each fellow should obtain experience in counseling young women of childbearing age with CHD regarding these potential risks. Fellows should understand the hematologic changes that occur during pregnancy and develop appropriate therapeutic strategies for women with heart disease requiring anticoagulation during pregnancy (26). They should be educated regarding appropriate contraceptive choices in young patients with CHD and provide counseling regarding contraceptive choices (27,28). Each fellow should get exposure to the multidisciplinary team with the maternal-fetal medicine group to care for pregnant young women with CHD. Additionally, pediatric cardiology fellows should be educated in the acute care management of cardiac issues that can arise (i.e., hypertension, arrhythmias) during pregnancy in women with underlying CHD (21).

### 3.10. Assessment of Sexual Function

Among patients with cardiovascular disease, sexual problems are highly prevalent in both men and women, and have been shown to adversely affect the patients' quality of life and well-being (29). To date, the discussion of sexual dysfunction in adults with CHD is often neglected. Recent studies have described an increased prevalence of erectile dysfunction (30), decreased sexual esteem, and/or distress with sex in adults with CHD (31).

Therefore, it is important for fellows to understand the complex relationship between cardiovascular disease, erectile dysfunction, and endothelial dysfunction (32). Endothelial dysfunction is not only an important process in the development of atherosclerotic cardiovascular disease, but also plays a role in the pathophysiologic mechanisms that contribute to erectile dysfunction. Sexual activity is reasonable in most adult congenital patients who do not have decompensated heart failure, severe valvular disease, or uncontrolled arrhythmias (Class IIa, *Level of Evidence: C*) (33).

### 3.11. Knowledge of the Legislative Aspects of Employment and Advocacy

Key aspects of providing quality of care for the adult with CHD include addressing not only late medical and surgical complications, but also the numerous social and psychological adjustments that affect day-to-day life. This includes vocational planning that should begin in

**TABLE 2 Core Curricular Competencies and Evaluation Tools for ACHD**

**Medical Knowledge**
- Know the unique aspects of caring for cyanotic adults, including Eisenmenger syndrome and pulmonary vascular disease.
- Know the electrophysiological abnormalities specific to ACHD patients.
- Know the mental health and cognitive outcomes in ACHD patients.
- Know the complex relationship between cardiovascular disease, erectile dysfunction, and endothelial dysfunction.

*Evaluation Tools: direct observation, conference participation and presentation, and in-training examination*

**Patient Care and Procedural Skill**
- Have the skills to manage the transition from adolescence to adulthood care of congenital heart disease.
- Have the skills to recognize concomitant adult medical conditions in ACHD patients.
- Have the skills to manage advanced heart failure and determine transplant candidacy in ACHD patients.
- Have the skills to initiate palliative care when appropriate.
- Have the skills to assess safety for ACHD patients to participate in sports and exercise.
- Have the skills to manage reproductive health issues in women with ACHD (i.e., contraception and pregnancy).

*Evaluation Tools: direct observation, conference participation, in-training examination, and procedure logs*

**Systems-Based Practice**
- Know the legislative aspects of employment and advocacy in ACHD patients.

*Evaluation Tools: direct observation, conference participation, and in-training examination*

ACHD indicates adult congenital heart disease.

adolescence so that appropriate educational options have been established long before the patient enters the work force (34). Although reports of employment status vary with CHD, no more than 10% are considered totally disabled (35). As many adults with CHD prepare to enter the job market and establish a career (36), careful consideration of both physical and psychological capabilities should be discussed with their cardiologist so that realistic employment options are explored. Crossland et al. (37) demonstrated that structured career and employment advice has been shown to be associated with a higher rate of employment (73%) than no such counseling (46%). Therefore, a review of the AHA published guidelines "Recreational and Occupational Recommendations for Young Patients With Heart Disease" (38) with patients with CHD and their parents should be performed to objectively assist with occupational counseling.

Knowledge of the legislative aspects of employment and advocacy may not be routine in the outpatient assessment in the adult with complex CHD. However, keys to overcoming these barriers include the development of educational materials or handouts to help adolescents and young adult patients as they approach the job market that focus on legal rights and tips for job success and where to go for job training and/or vocational counseling. The involvement of an adult congenital medical social worker who is knowledgeable of state programs is most helpful to optimize opportunities.

The core curricular competencies for pediatric transition to ACHD are summarized in **Table 2**, grouped by ACGME core competency domain, and showing corresponding evaluation tools.

## 4. ADVANCED TRAINING: GOALS AND METHODS

Advanced ACHD training requires an additional 2 years after completion of either pediatric cardiology or adult cardiovascular disease training. The specifics of the ACHD training pathways are being developed and a summary of the proposed requirements are listed in **Table 3**.

## 5. EVALUATION AND DOCUMENTATION OF COMPETENCE

All training programs should include written goals and objectives for each ACHD rotation, with performance goals set according to the fellow's level of training. These will serve as the basis for formative feedback. A copy of these goals and objectives should be supplied and explained to the trainee at the onset of fellowship training and reviewed at the beginning of each rotation. Evaluation of fellows should be performed midway through, and at the completion of, each rotation;

**TABLE 3 Advanced Training in Adult Congenital Heart Disease: Proposed Requirements Applicable to Trainees From a Pediatric Cardiology Training Background**

- Participate in a regular outpatient clinic organized to care for adults with congenital heart disease. The trainee should be involved in the care of at least 10 clinic patients per week, ideally at least 1 clinic per week, although more may be necessary.
- Experience a range of diagnostic and therapeutic methods used in the care of adults with CHD, including direct experience in echocardiography, magnetic resonance imaging, computed tomography, diagnostic catheterization, and exercise testing.
- Participate in the perioperative evaluation of adults with CHD for both cardiac and noncardiac procedures and observe operative repairs.
- Participate in outpatient evaluation and inpatient management of pregnancy in women with CHD.
- Participate in inpatient and outpatient management of adults with CHD and heart failure and/or pulmonary arteriolar hypertension. Participate in medical management of these patients, as well as exposure to discussion/implementation of mechanical circulatory support and transplant as options for treatment.
- Participate in the diagnosis and management of the arrhythmic complications seen in adults with CHD, both medical therapy and interventional options.
- For those with training in pediatric cardiology, but not adult cardiology, participate in the internal medicine rotations that focus on acquired medical and cardiac disease that affect adults with CHD. This can include inpatient and outpatient general adult cardiology, heart failure/transplant, and noncardiology specialties.

CHD indicates congenital heart disease.

evaluations should be directed toward whether the fellow met those prespecified aims. The fellow evaluation should be performed by the ACHD director and/or senior ACHD physician. The fellow evaluation should assess the fellow's performance in each of the 6 areas of core competencies, as appropriate for the level of training, and should be based on direct observation of the fellow. Evaluation of competency in preparation, performance, and interpretation of the results of a procedure should be given more consideration than a focus on the number of procedures performed. Evaluation of competency should be done in person with the trainee and documented in his or her fellowship record. If the trainee is not progressing as expected, remedial actions should be arranged and documented in accordance with institutional procedures. All fellows should maintain a log (preferably electronic) of all procedures performed.

## REFERENCES

**1.** Warnes CA, Bhatt AB, Daniels, et al. COCATS 4 task force 14: training in the care of adult patients with congenital heart disease. J Am Coll Cardiol. 2015;65:1887–98.

**2.** Warnes CA, Williams RG, Bashore TM, et al. ACC/AHA 2008 guidelines for the management of adults with congenital heart disease: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Writing Committee to Develop Guidelines on the Management of Adults With Congenital Heart Disease). J Am Coll Cardiol. 2008;52:e143–263.

**3.** Warnes CA, Liberthson R, Danielson GK, et al. Task force 1: the changing profile of congenital heart disease in adult life. J Am Coll Cardiol. 2001;37:1170–5.

**4.** Walsh EP, Cecchin F. Arrhythmias in adult patients with congenital heart disease. Circulation. 2007;115:534–45.

**5.** January CT, Wann LS, Alpert JS, et al. 2014 AHA/ACC/HRS guideline for the management of patients with atrial fibrillation: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines and the Heart Rhythm Society [erratum appears in J Am Coll Cardiol 2014;64:2305–7]. J Am Coll Cardiol. 2014;64:e1–76.

**6.** Book WM. Heart failure in the adult patient with congenital heart disease. J Card Fail. 2005;11:306–12.

**7.** Norozi K, Wessel A, Alpers V, et al. Incidence and risk distribution of heart failure in adolescents and adults with congenital heart disease after cardiac surgery. Am J Cardiol. 2006;97:1238–43.

**8.** Mahle WT, Todd K, Fyfe DA. Endothelial function following the Fontan operation. Am J Cardiol. 2003;91:1286–8.

**9.** Binotto MA, Maeda NY, Lopes AA. Altered endothelial function following the Fontan procedure. Cardiol Young. 2008;18:70–4.

**10.** Shaddy RE, Webb G. Applying heart failure guidelines to adult congenital heart disease patients. Expert Rev Cardiovasc Ther. 2008;6:165–74.

**11.** Bolger AP, Sharma R, Li W, et al. Neurohormonal activation and the chronic heart failure syndrome in adults with congenital heart disease. Circulation. 2002;106:92–9.

**12.** Clark JB, Pauliks LB, Myers JL, et al. Mechanical circulatory support for end-stage heart failure in repaired and palliated congenital heart disease. Curr Cardiol Rev. 2011;7:102–9.

**13.** Speziali G, Driscoll DJ, Danielson GK, et al. Cardiac transplantation for end-stage congenital heart defects: the Mayo Clinic experience. Mayo Cardiothoracic Transplant Team. Mayo Clin Proc. 1998;73:923–8.

**14.** Gatzoulis MA. The management of Eisenmenger syndrome in the modern treatment era: a case report. Eur Respir Rev. 2011;20:293–6.

**15.** Lowe BS, Therrien J, Ionescu-Ittu R, et al. Diagnosis of pulmonary hypertension in the congenital heart disease adult population: impact on outcomes. J Am Coll Cardiol. 2011;58:538–46.

**16.** Diller GP, Gatzoulis MA. Pulmonary vascular disease in adults with congenital heart disease. Circulation. 2007;115:1039–50.

**17.** Dimopoulos K, Inuzuka R, Goletto S, et al. Improved survival among patients with Eisenmenger syndrome receiving advanced therapy for pulmonary arterial hypertension. Circulation. 2010;121:20–5.

**18.** American Psychiatric Association. Diagnostic and Statistical Manual of Mental Disorders. 4th edition. Washington, DC: American Psychiatric Association, 1994.

**19.** Williams NM, Owen MJ. Genetic abnormalities of chromosome 22 and the development of psychosis. Curr Psychiatry Rep. 2004;6:176–82.

**20.** Maron BJ, Zipes DP. Introduction: eligibility recommendations for competitive athletes with cardiovascular abnormalities-general considerations. J Am Coll Cardiol. 2005;45:1318–21.

**21.** Regitz-Zagrosek V, Blomstrom LC, Borghi C, et al. ESC guidelines on the management of cardiovascular diseases during pregnancy: the Task Force on the Management of Cardiovascular Diseases during Pregnancy of the European Society of Cardiology (ESC). Eur Heart J. 2011;32:3147–97.

**22.** Siu SC, Sermer M, Colman JM, et al. Prospective multicenter study of pregnancy outcomes in women with heart disease. Circulation. 2001;104:515–21.

**23.** Drenthen W, Pieper PG, Roos-Hesselink JW, et al. Outcome of pregnancy in women with congenital heart disease: a literature review. J Am Coll Cardiol. 2007;49:2303–11.

**24.** Khairy P, Ouyang DW, Fernandes SM, et al. Pregnancy outcomes in women with congenital heart disease. Circulation. 2006;113:517–24.

**25.** Balint OH, Siu SC, Mason J, et al. Cardiac outcomes after pregnancy in women with congenital heart disease. Heart. 2010;96:1656–61.

**26.** James AH. Pregnancy-associated thrombosis. Hematology Am Soc Hematol Educ Program. 2009:277–85.

**27.** Kovacs AH, Harrison JL, Colman JM, et al. Pregnancy and contraception in congenital heart disease: what women are not told. J Am Coll Cardiol. 2008;52:577–8.

**28.** Thorne S, MacGregor A, Nelson-Piercy C. Risks of contraception and pregnancy in heart disease. Heart. 2006;92:1520–5.

**29.** Drory Y, Kravetz S, Weingarten M. Comparison of sexual activity of women and men after a first acute myocardial infarction. Am J Cardiol. 2000;85:1283–7.

**30.** Cook SC, Arnott LM, Nicholson LM, et al. Erectile dysfunction in men with congenital heart disease. Am J Cardiol. 2008;102:1728–30.

**31.** Winter MM, Reisma C, Kedde H, et al. Sexuality in adult patients with congenital heart disease and their partners. Am J Cardiol. 2010;106:1163–8.e8.

**32.** Vlachopoulos C, Ioakeimidis N, Terentes-Printzios D, Stefanadis C. The triad: erectile dysfunction—endothelial dysfunction—cardiovascular disease. Curr Pharm Des. 2008;14:3700–14.

**33.** Levine GN, Steinke EE, Bakaeen FG, et al. Sexual activity and cardiovascular disease: a scientific statement from the American Heart Association. Circulation. 2012;125:1058–72.

**34.** Sable C, Foster E, Uzark K, et al. Best practices in managing transition to adulthood for adolescents with congenital heart disease: the transition process and medical and psychosocial issues: a scientific statement from the American Heart Association. Circulation. 2011;123:1454–85.

**35.** Skorton DJ, Garson A Jr., Allen HD, et al. Task force 5: adults with congenital heart disease: access to care. J Am Coll Cardiol. 2001;37:1193–8.

**36.** Moons P, Van DK, Marquet K, et al. Individual quality of life in adults with congenital heart disease: a paradigm shift. Eur Heart J. 2005;26:298–307.

**37.** Crossland DS, Jackson SP, Lyall R, et al. Employment and advice regarding careers for adults with congenital heart disease. Cardiol Young. 2005;15:391–5.

**38.** Gutgesell HP, Gessner IH, Vetter VL, Yabek SM, Norton JB Jr. Recreational and occupational recommendations for young patients with heart disease: a statement for physicians by the Committee on Congenital Cardiac Defects of the Council on Cardiovascular Disease in the Young, American Heart Association. Circulation. 1986;74:1195A–8.

**KEY WORDS** SPCTPD/ACC/AAP/AHA Training Statement, clinical competence, congenital heart disease, fellowship training, high-risk pregnancy, pediatric cardiology, transition of care

## APPENDIX 1. AUTHOR RELATIONSHIPS WITH INDUSTRY AND OTHER ENTITIES (RELEVANT)—TASK FORCE 6: PEDIATRIC CARDIOLOGY FELLOWSHIP TRAINING IN ADULT CONGENITAL HEART DISEASE

| Committee Member | Employment | Consultant | Speakers Bureau | Ownership/ Partnership/ Principal | Personal Research | Institutional/ Organizational or Other Financial Benefit | Expert Witness |
|---|---|---|---|---|---|---|---|
| Karen Stout *(Co-Chair)* | University of Washington—Director, Adult Congenital Heart Disease Program; Professor, Medicine; Adjunct Professor, Pediatrics | None | None | None | None | None | None |
| Anne Marie Valente *(Co-Chair)* | Boston Children's Hospital, Brigham and Women's Hospital—Boston Adult Congenital Heart (BACH) Program Outpatient Director and BACH Senior Fellowship Co-Director; Harvard Medical School—Associate Professor of Pediatrics and Medicine | None | None | None | None | None | None |
| Peter J. Bartz | Children's Hospital of Wisconsin, Medical College of Wisconsin—Associate Professor of Pediatrics & Medicine; Director, Clinical Cardiology; and Director, Pediatric Cardiology Fellowship Program | None | None | None | None | None | None |
| Stephen Cook | Children's Heart Institute of Pittsburgh of UPMC—Associate Professor of Internal Medicine & Pediatrics, and Director, Adolescent and Young Adult Congenital Heart Disease Center | None | None | None | None | None | None |
| Michelle Gurvitz | Boston Children's Hospital, Brigham and Women's Hospital, Harvard Medical School—Assistant Professor, Pediatrics | None | None | None | None | None | None |
| Arwa Saidi | University of Florida—Director, Adult Congenital Heart Disease Program, and Professor, Departments of Pediatric and Internal Medicine | None | None | None | None | None | None |
| Robert D. Ross | Children's Hospital of Michigan, Wayne State University School of Medicine—Director of Fellowship Programs and The Pulmonary Hypertension Program | None | None | None | None | None | None |

For the purpose of developing a general cardiology training statement, the American College of Cardiology (ACC) determined that no relationships with industry (RWI) or other entities were relevant. This table reflects authors' employment and reporting categories. To ensure complete transparency, authors' comprehensive healthcare-related disclosure information—including RWI not pertinent to this document—is available in an online data supplement. Please refer to http://www.acc.org/guidelines/about-guidelines-and-clinical-documents/relationships-with-industry-policy for definitions of disclosure categories, relevance, or additional information about the ACC Disclosure Policy for Writing Committees.

## APPENDIX 2. PEER REVIEWER RELATIONSHIPS WITH INDUSTRY AND OTHER ENTITIES (RELEVANT)—TASK FORCE 6: PEDIATRIC CARDIOLOGY FELLOWSHIP TRAINING IN ADULT CONGENITAL HEART DISEASE

| Name | Employment | Representation | Consultant | Speakers Bureau | Ownership/ Partnership/ Principal | Personal Research | Institutional/ Organizational or Other Financial Benefit | Expert Witness |
|---|---|---|---|---|---|---|---|---|
| Regina Lantin-Hermoso | Texas Children's Hospital | ACC ACPC Council | None | None | None | None | None | None |
| Carole Warnes | Mayo Clinic—Professor, Medicine | ACC BOT | None | None | None | None | None | None |
| Eric Williams | Indiana University School of Medicine—Professor (Cardiology) and Associate Dean; Indiana University Health, Cardiology Service Line Leader | ACC CMC Lead Reviewer | None | None | None | None | None | None |

For the purpose of developing a general cardiology training statement, the ACC determined that no relationships with industry or other entities were relevant. This table reflects peer reviewers' employment, representation in the review process, as well as reporting categories. Names are listed in alphabetical order within each category of review. Please refer to http://www.acc.org/guidelines/about-guidelines-and-clinical-documents/relationships-with-industry-policy for definitions of disclosure categories, relevance, or additional information about the ACC Disclosure Policy for Writing Committees.

ACC indicates American College of Cardiology; ACPC, Adult Congenital and Pediatric Cardiology; BOT, Board of Trustees; and CMC, Competency Management Committee.

JOURNAL OF THE AMERICAN COLLEGE OF CARDIOLOGY
© 2015 BY THE SOCIETY OF PEDIATRIC CARDIOLOGY TRAINING PROGRAM DIRECTORS, AMERICAN COLLEGE OF CARDIOLOGY FOUNDATION, AMERICAN ACADEMY OF PEDIATRICS, AND THE AMERICAN HEART ASSOCIATION, INC.
PUBLISHED BY ELSEVIER INC.

VOL. 66, NO. 6, 2015
ISSN 0735-1097/$36.00
http://dx.doi.org/10.1016/j.jacc.2015.03.013

TRAINING STATEMENT

# Task Force 7: Pediatric Cardiology Fellowship Training in Pulmonary Hypertension, Advanced Heart Failure, and Transplantation

Steven A. Webber, MB, ChB, *Co-Chair*
Daphne T. Hsu, MD, FAAP, FACC, FAHA, *Co-Chair*
D. Dunbar Ivy, MD, FAAP, FACC
Thomas J. Kulik, MD
Elfriede Pahl, MD, FAAP, FACC
David N. Rosenthal, MD
W. Robert Morrow, MD, FAAP, FACC
Jeffrey A. Feinstein, MD

## 1. INTRODUCTION

### 1.1. Document Development Process

The Society of Pediatric Cardiology Training Program Directors (SPCTPD) board assembled a Steering Committee that nominated 2 chairs, 1 SPCTPD Steering Committee member, and 5 additional members from a wide range of program sizes, geographic regions, and subspecialty focuses. Representatives from the American College of Cardiology (ACC), American Academy of Pediatrics (AAP), and American Heart Association (AHA) participated. The Steering Committee member was added to provide perspective to each Task Force as a "nonexpert" in that field. Relationships with industry and other entities were not deemed relevant to the creation of a general cardiology training statement; however, employment and affiliation information for authors and peer reviewers are provided in Appendixes 1 and 2, respectively, along with disclosure reporting categories. Comprehensive disclosure information for all authors, including relationships with industry and other entities, is available as an online supplement to this document.

The writing committee developed the document, approved it for review by individuals selected by the participating organizations (Appendix 2), and addressed their comments. The final document was approved by the SPCTPD, AAP, and AHA in February 2015 and approved by the ACC in March 2015. This document is considered current until the SPCTPD revises or withdraws it.

### 1.2. Background and Scope

The availability of effective pharmacological and surgical treatments for children with pulmonary hypertension (PH) or advanced heart failure has grown rapidly over the past decade (1-3). Although the care of children with these diseases is often coordinated by specialized centers, pediatric cardiologists are increasingly called upon to evaluate and participate in the care of children with PH or advanced heart failure and those who have undergone thoracic organ transplantation. Thus, core training in pediatric cardiology must include sufficient clinical exposure and didactic opportunities for the trainee to gain competency in the evaluation and management of children with these diseases. In addition, for the general pediatric cardiologist to counsel patients and make appropriate referrals, core training must include exposure to key concepts in advanced care of these diseases, including the indications, risks, and benefits of

The American College of Cardiology requests that this document be cited as follows: Webber SA, Hsu DT, Ivy DD, Kulik TJ, Pahl E, Rosenthal DN, Morrow R, Feinstein JA. Task force 7: pediatric cardiology fellowship training in pulmonary hypertension, advanced heart failure, and transplantation. J Am Coll Cardiol 2015;66:732-9.

This article is copublished in *Circulation*.

pulmonary vasodilator therapy, mechanical circulatory support, and heart, lung, or heart-lung transplantation (3). The requirements for core training in PH and advanced heart failure for all trainees seeking board certification in pediatric cardiology are outlined in the next sections. Advanced requirements are much more comprehensive, require a dedicated period of training, and apply only to practitioners planning to subspecialize in the care of children with these diseases.

Our revised training recommendations describe the program resources and environment that are required for training pediatric cardiology fellows, together with a competency-based system promulgated by the Accreditation Council of Graduate Medical Education (ACGME), to implement specific goals and objectives for training pediatric cardiology fellows. This system categorizes competencies into 6 core competency domains: Medical Knowledge, Patient Care and Procedural Skills, Systems-Based Practice, Practice-Based Learning and Improvement, Professionalism, and Interpersonal and Communication Skills, along with identification of suggested evaluation tools for each domain. Core competencies unique to pediatric PH and heart failure are listed in Sections 2.2 and 3.2, respectively (see the "2015 SPCTPD/ACC/AAP/AHA Training Guidelines for Pediatric Cardiology Fellowship Programs [Revision of the 2005 Training Guidelines for Pediatric Cardiology Fellowship Programs]: Introduction" for additional competencies that apply to all Task Force reports).

### 1.3. Levels of Expertise—Core and Advanced

Core training must be available at all centers with a fellowship program in pediatric cardiology. The core curriculum described in Sections 2.2 (PH) and 3.2 (heart failure) is intended to be sufficient for fellows who do not plan a formal career in PH, advanced heart failure, or cardiac transplantation. Core training is required for all trainees and is intended to ensure that fellows acquire the knowledge base and skills necessary to become a pediatric cardiologist referring his/her patient for specialized care in these areas. Advanced training guidelines are recommended for fellows who wish to specialize in PH, advanced heart failure, and cardiac transplantation training. Advanced training should only take place at select centers with a sufficient patient volume that prepares the trainee for clinical practice involving invasive procedures.

## 2. PULMONARY HYPERTENSION

### 2.1. Program Resources and Environment

Training in PH should be performed in a program approved by the ACGME. The pediatric faculty responsible for teaching this curriculum should have expertise in PH, critical care medicine, neonatal medicine, cardiology, echocardiography, cardiac catheterization, genetics, and pulmonary medicine. In some centers, the primary service caring for PH patients will be the pulmonary service; thus, training may occur under the supervision of the pulmonary medicine service. Trainees optimally will participate in evaluation and treatment in multiple inpatient and outpatient settings. The following are venues for providing care in pediatric PH: the outpatient clinic, consultation service, ward and intensive care units (pediatric and neonatal), noninvasive imaging laboratory, and cardiac catheterization laboratory.

### 2.2. Core Training: Goals and Methods

In formulating core training requirements, it is expected that all board-certified pediatric cardiologists should be able to: 1) perform the initial evaluation and management of the child with PH in the outpatient ambulatory setting; 2) perform the initial evaluation and stabilization of the hemodynamically compromised patient with PH; 3) understand the indications, risks, and benefits of medications used for the treatment of PH; and 4) understand the indications and appropriate timing of referral to a dedicated specialist in pediatric or adult PH for advanced care.

#### 2.2.1. General Requirements

At the end of the 3-year pediatric cardiology fellowship, the board-eligible pediatric cardiologist should be able to evaluate and provide the initial treatment of neonates, infants, children, and adolescents with PH of various etiologies described in **Table 1**. Suggested evaluation tools to assess competence are denoted in the table.

#### 2.2.2. Specific Areas of Knowledge and Competence

The board-eligible pediatric cardiologist should have knowledge in the following areas of PH physiology, evaluation, and treatment and be able to apply specific knowledge to the care of an infant, child, and adolescent with PH.

##### 2.2.2.1. Physiology

- Normal pulmonary vascular physiology, including the "neonatal transition" in pulmonary vascular resistance
- Distinction between PH and elevated pulmonary vascular resistance (i.e., hypertensive pulmonary vascular disease)
- Pulmonary vascular pathophysiology, including the physiological and clinical meaning of "reactivity" to vasodilators as reactivity relates to suitability for surgical repair as opposed to indications for calcium channel blocker therapy in the outpatient setting
- Indications/contraindications for repair of congenital cardiac lesions in the presence of pulmonary vascular disease

**TABLE 1 Core Curricular Competencies and Evaluation Tools for Pediatric PH**

**Medical Knowledge**
- Know the difference between PH and PAH.
- Know the use of FDA-approved medications in adults with PAH and medications commonly used in pediatric patients with PAH, including understanding of important drug interactions and adverse effects of medications.
- Know the indications, risks, benefits, and outcomes of lung or heart–lung transplantation in children with PH.

*Evaluation Tools: direct observation, conference participation and presentation, procedure logs, and in-training examination*

**Patient Care and Procedural Skills**
- Have the skills to identify the common presenting clinical features of PH.
- Have the skills to interpret pertinent findings on echocardiogram for patients with PH.
- Have the skills to perform key components of an initial evaluation of PH that is due to multiple etiologies, including: persistent PH of the newborn, congenital heart disease (including Eisenmenger physiology), PH associated with left heart disease, PH associated with chronic lung disease, and idiopathic PAH.
- Have the skills to plan an appropriate referral for consultation with a dedicated specialist in pediatric or adult PH.
- Have the skills to apply available outcome data for children treated with targeted PH therapy to the care of a patient with PH.
- Have the skills to counsel families regarding the acute and chronic care of the child with PH.

*Evaluation Tools: direct observation, conference participation, and procedure logs*

FDA indicates U.S. Food and Drug Administration; PAH, pulmonary artery hypertension; and PH, pulmonary hypertension.

- Normal right ventricular function, as well as acute and chronic right ventricular dysfunction
- Interactions and relationships between the right and left ventricles in normal physiology and in the setting of pulmonary vascular diseases
- Pathophysiology of congenital heart disease with intracardiac or arterial level shunt, including Eisenmenger physiology
- Physiology of the patient with pulmonary artery hypertension (PAH) that is due to pulmonary venous hypertension

#### 2.2.2.2. Clinical Evaluation, Imaging, and Hemodynamics

- Identify the common presenting symptoms and physical examination findings in patients with PH with and without congenital heart disease.
- Identify the common presenting signs and symptoms of right and left heart failure.
- Indications, risks, and benefits of techniques commonly used to evaluate patients with PH, including electrocardiography, echocardiography, cardiac magnetic resonance imaging, cardiac computed tomography, ventilation, and perfusion lung scans
- Indications, risks, and benefits of cardiac catheterization and vasodilator testing

#### 2.2.2.3. Classification

- Understand the World Health Organization Classification of PH.

#### 2.2.2.4. Genetics

- Understand patterns of heritable PAH.
- Understand genetic tests relevant to heritable PH.

#### 2.2.2.5. Treatment

- Cardiovascular pharmacology. Understand the indications, mechanisms of action, appropriate routes of administration, and adverse effects of the following medications used to treat PAH and understand the potential drug-drug interactions between the specific PAH therapies and other medications used to treat PAH. Currently relevant medications include:
  - PDE-5 inhibitors (sildenafil, tadalafil)
  - Endothelin receptor antagonists (bosentan, ambrisentan, macitentan)
  - Prostacyclin analogues (epoprostenol, treprostinil, iloprost)
  - Inhaled nitric oxide
  - Diuretics
  - Warfarin
  - Soluble guanylate cyclase stimulators (riociguat)
- Indications, risks, benefits, and outcomes of short- and long-term mechanical circulatory support in the treatment of patients with PH, including extracorporeal membrane oxygenator and ventricular assist devices
- Indications, risks, benefits, and outcomes of lung or heart lung transplantation in the treatment of patients with PH

### 2.2.3. Evaluation and Documentation of Competence

All training programs should include written goals and objectives for evaluation and care of patients with PH with performance goals set according to the fellow's level of training. These will serve as the basis for formative feedback. A copy of these goals and objectives should be supplied and explained to the trainee at the onset of fellowship training and reviewed at the beginning of each year. Evaluation of fellows should be performed midway through, and at the completion of, each rotation; evaluations should be directed toward whether the fellow met those prespecified aims. The fellow evaluation should assess the fellow's performance in each of the 6 areas of core competencies, as appropriate for the level of training, and should be based on direct observation of the fellow. Evaluation of competency in preparation, performance, and interpretation of the results of a procedure should be given more consideration than a focus on the

number of procedures performed. Evaluation of competency should be done in person with the trainee and documented in the fellowship record. If the trainee is not progressing as expected, remedial actions should be arranged and documented in accordance with institutional procedures. All fellows should maintain a log (preferably electronic) of all PH patients. Trainees should participate in diagnosis and treatment of a minimum of 20 patients (10 inpatient and 10 outpatient) during the 3 years of training to ensure adequate clinical exposure and enable sufficient opportunities for assessment by the clinical competency committees and their program directors.

### 2.3. Advanced Training: Goals and Methods

Advanced trainees in PAH require a dedicated 6- to 12-month time period working with a comprehensive pediatric PH program. All advanced trainees should have a rigorous (bench, clinical, or translational) research training experience pertinent to PH as part of (or prior to) their advanced training.

At the completion of the advanced training fellowship, the trainee should undergo a competency assessment that establishes the ability to independently perform a comprehensive evaluation of a patient with PH. The trainee should be able to formulate and execute a treatment plan based on the evaluation in conjunction with a PH subspecialist. Clinical competence should be assessed using a combination of direct observation of clinical performance and structured interviews by a PH subspecialist.

## 3. ADVANCED HEART FAILURE

### 3.1. Program Resources and Environment

Training in pediatric heart failure and transplantation should be performed in a program approved by the ACGME. Although not all programs will have a dedicated team for the management and treatment of advanced pediatric heart failure and transplantation, clinical expertise can be found in the subspecialties of general cardiology, noninvasive imaging, cardiac catheterization, electrophysiology, critical care, neonatology, cardiothoracic surgery, and genetics. Training programs should have a relationship with a center that provides advanced heart failure care (ventricular assist devices and transplantation). Faculty from these specialized centers may enhance fellowship training by providing didactics or clinical experience in advanced heart failure and transplantation. Trainees should participate in the treatment of patients with heart failure and transplantation, including the evaluation and treatment in multiple inpatient and outpatient settings. The following are venues for providing training in pediatric heart failure and transplantation: the outpatient clinic, the consultation service, the ward and the intensive care unit, and the noninvasive and cardiac catheterization laboratory.

### 3.2. Core Training: Goals and Methods

In formulating the core training requirements, it is expected that all board-certified pediatric cardiologists would be proficient in the following: 1) evaluation and treatment of the ambulatory child with heart failure; 2) initial evaluation and stabilization of the hemodynamically compromised patient with heart failure; 3) administration of medications approved or commonly used for the treatment of heart failure; 4) appropriate referral to dedicated specialist for consideration of advanced management options, including mechanical circulatory support and transplantation evaluation; and 5) shared cardiology care, with a specialized center, of a recipient who has undergone transplantation (4,5).

#### 3.2.1. General Requirements

At the end of the 3-year pediatric cardiology fellowship, the board-eligible pediatric cardiologist should be able to perform the competencies shown in **Table 2**. Suggested evaluation tools to assess competence are denoted in the table.

#### 3.2.2. Specific Areas of Knowledge and Competence

The board-eligible pediatric cardiologist will have the following areas of knowledge and be able to apply the knowledge to the care of an infant, child, or adolescent with heart failure:

##### 3.2.2.1. Physiology

- Understand the pathophysiology of heart failure in children with congenital and acquired heart diseases.
- Recognize the impact of the systolic and diastolic function of the left and right ventricles on cardiac output.
- Understand the interactions and relationships between the right and left ventricles in normal physiology and in the setting of congenital heart disease and cardiomyopathies.
- Understand the effect of congenital heart defects on the manifestations of heart failure.

##### 3.2.2.2. Diagnostic Techniques

- Recognize the symptoms and identify the signs of heart failure, including right-sided congestion, pulmonary overcirculation and edema, low cardiac output, and rhythm disorders.
- Interpret results of noninvasive techniques commonly used to evaluate patients with heart failure (e.g., biomarkers, echocardiography, exercise testing, cardiac magnetic resonance imaging).

**TABLE 2 Core Curricular Competencies and Evaluation Tools for Advanced Pediatric Heart Failure**

| |
|---|
| **Medical Knowledge** |
| ■ Know the signs and symptoms of heart failure in children. |
| ■ Know the role of extracorporeal membrane oxygenator support, ventricular assist device support, and transplantation in the treatment of end-stage heart failure. |
| ■ Know the indications, mechanism of actions, risks, and benefits associated with the FDA-approved medications for use in adults with heart failure and medications commonly used in pediatric patients with heart failure. |
| *Evaluation Tools: direct observation, conference participation and presentation, procedure logs, and in-training examination* |
| **Patient Care and Procedural Skills** |
| ■ Have the skills to evaluate and provide initial treatment for pediatric patients with heart failure of various etiologies. |
| ■ Have the skills to develop a differential diagnosis in a child with heart failure. |
| ■ Have the skills to establish an accurate diagnosis for the child with heart failure utilizing noninvasive imaging, genetic evaluation, endomyocardial biopsy, and cardiac catheterization. |
| ■ Have the skills to evaluate the clinical condition of the heart failure patient and interpret the results of arrhythmia testing, exercise testing, biomarker levels, noninvasive imaging, and cardiac catheterization to plan the appropriate treatment. |
| ■ Have the skills to initiate medical therapies to treat heart failure, including anticongestive medications, antiarrhythmic medications, inotropic support, and neurohormonal blockade (e.g., angiotensin-converting enzyme inhibitors, beta-blockers). |
| ■ Have the skills to plan appropriate consultation with a dedicated specialist in pediatric advanced heart failure therapies. |
| *Evaluation Tools: direct observation, conference participation, and procedure logs* |

FDA indicates U.S. Food and Drug Administration.

- Know the indications, risks, and benefits of cardiac catheterization and endomyocardial biopsy in the evaluation of children with heart failure or cardiomyopathy.
- Know the hemodynamic findings associated with systolic and diastolic heart failure.
- Know how to evaluate pulmonary vascular resistance in heart failure patients.
- Understand the uses and limitations of serial monitoring with currently available biomarkers for heart failure.

#### 3.2.2.3. Cardiovascular Pharmacology

The trainee should learn mechanisms, indications for use, and side effects of pharmacologic agents used to treat pediatric heart failure:

- Diuretics
- Inotropic agents
- Vasodilators
- Vasoconstrictors
- Inhaled nitric oxide
- Anticoagulants
- Antiarrhythmics
- Neurohormonal blockade
- Cardiac glycosides

#### 3.2.2.4. Classification (6,7)

- Know the common classifications of cardiomyopathies (e.g. morphological, genetic, physiological).
- Know the clinical classifications of heart failure commonly used in children and know the stages of heart failure.

#### 3.2.2.5. Arrhythmia Management

- Identify the arrhythmias associated with heart failure.
- Plan the pharmacological management of arrhythmias.
- Understand the indications, risks, and benefits of implantable defibrillator and resynchronization therapy.

#### 3.2.2.6. Mechanical Circulatory Support (8)

- Know the indications, risks, and benefits of extracorporeal membrane oxygenator support and ventricular assist devices.
- Understand the physiology of extracorporeal membrane oxygenator support and ventricular assist devices.
- Know the outcomes of extracorporeal membrane oxygenation and mechanical circulatory support in heart failure.

#### 3.2.2.7. Understand the Consensus Guidelines for the Treatment of Heart Failure

- 2013 ACCF/AHA Guideline for the Management of Heart Failure (9)
- ISHLT: Practice Guidelines for Management of Heart Failure in Children (4)

#### 3.2.2.8. Heart Transplantation (10,11)

- Know the outcomes of heart transplantation, including mortality and major morbidities.
- Know the indications and contraindications for heart transplantation.
- Know the incidence of the common complications associated with heart transplantation.
- Understand the physiology of the denervated, transplanted heart.
- Know the common adverse events and drug interactions associated with immunosuppressive medications used in patients following heart transplantation.
- Know the uses and limitations of techniques commonly used to evaluate heart transplant patients for rejection (clinical, echocardiogram, electrocardiogram, cardiac catheterization, endomyocardial biopsy).

#### 3.2.2.9. Genetics (12)

- Understand patterns of heritable cardiomyopathies.
- Understand genetic tests relevant to cardiomyopathies.

### 3.2.3. Evaluation and Documentation of Competence

All training programs should include written goals and objectives for evaluation and care of patients with heart failure with performance goals set according to the fellow's level of training. These will serve as the basis for formative feedback. A copy of these goals and objectives should be supplied and explained to the trainee at the onset of fellowship training and reviewed at the beginning of each year. Evaluation of fellows should be performed midway through, and at the completion of, each rotation; evaluations should be directed toward whether the fellow met those prespecified aims. The fellow evaluation should assess the fellow's performance in each of the 6 areas of core competencies, as appropriate for the level of training, and should be based on direct observation of the fellow. Evaluation of competency in preparation, performance, and interpretation of the results of a procedure should be given more consideration than a focus on the number of procedures performed. Evaluation of competency should be done in person with the trainee and documented in the trainee's fellowship record. If the trainee is not progressing as expected, remedial actions should be arranged and documented in accordance with institutional procedures. All fellows should maintain a log (preferably electronic) of all heart failure patients. Trainees should participate in the care of at least 10 patients with advanced heart failure during the 3 years of fellowship to ensure adequate clinical exposure and enable sufficient opportunities for assessment by the clinical competency committees and their program directors.

## 3.3. Advanced Training: Goals and Methods

Advanced training in pediatric heart failure and transplantation requires a dedicated 12 months working with a comprehensive pediatric advanced heart failure service. The trainee should participate in the care of patients receiving advanced medical therapies, mechanical assist device support, and heart transplantation. The training program should have a United Network for Organ Sharing-approved pediatric transplantation program and allow the trainees to gain sufficient experience in the management of pediatric transplant candidates and recipients. All advanced trainees should have a rigorous (bench, clinical, or translational) research training experience pertinent to advanced heart failure and transplantation as part of (or prior to) their advanced training.

At the completion of the advanced training, the trainee should undergo a competency assessment that establishes the ability to independently perform a comprehensive evaluation of a patient with advanced heart failure, including an evaluation for heart transplantation. The trainee should be able to formulate and execute a treatment plan based on the evaluation in conjunction with an advanced heart failure specialist. Clinical competence should be assessed using a combination of direct observation of clinical performance and structured interviews by an advanced heart failure subspecialist.

## REFERENCES

**1.** Ivy DD, Abman SH, Barst RJ, et al. Pediatric pulmonary hypertension. J Am Coll Cardiol. 2013;62:D117–26.

**2.** Galie N, Hoeper MM, Humbert M, et al. Guidelines for the diagnosis and treatment of pulmonary hypertension. Eur Respir J. 2009;34:1219–63.

**3.** McLaughlin VV, Archer SL, Badesch DB, et al. ACCF/AHA 2009 expert consensus document on pulmonary hypertension a report of the American College of Cardiology Foundation Task Force on Expert Consensus Documents and the American Heart Association. In collaboration with the American College of Chest Physicians, American Thoracic Society, Inc., and the Pulmonary Hypertension Association. J Am Coll Cardiol. 2009;53:1573–619.

**4.** Rosenthal D, Chrisant MR, Edens E, et al. International Society for Heart and Lung Transplantation: practice guidelines for management of heart failure in children. J Heart Lung Transplant. 2004;23:1313–33.

**5.** McMurray JJ, Adamopoulos S, Anker SD, et al. ESC guidelines for the diagnosis and treatment of acute and chronic heart failure 2012: the Task Force for the Diagnosis and Treatment of Acute and Chronic Heart Failure 2012 of the European Society of Cardiology. Eur Heart J. 2012;33:1787–847.

**6.** Elliott P, Andersson B, Arbustini E, et al. Classification of the cardiomyopathies: a position statement from the European Society of Cardiology Working Group on Myocardial and Pericardial Diseases. Eur Heart J. 2008;29:270–6.

**7.** Maron BJ, Towbin JA, Thiene G, et al. Contemporary definitions and classification of the cardiomyopathies: an American Heart Association Scientific Statement from the Council on Clinical Cardiology, Heart Failure and Transplantation Committee; Quality of Care and Outcomes Research and Functional Genomics and Translational Biology Interdisciplinary Working Groups; and Council on Epidemiology and Prevention. Circulation. 2006;113:1807–16.

**8.** Feldman D, Pamboukian SV, Teuteberg JJ, et al. The 2013 International Society for Heart and Lung Transplantation guidelines for mechanical circulatory support: executive summary. J Heart Lung Transplant. 2013;32:157–87.

**9.** Yancy CW, Jessup M, Bozkurt B, et al. 2013 ACCF/AHA guideline for the management of heart failure: a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines. J Am Coll Cardiol. 2013;62:e147–239.

**10.** Costanzo MR, Dipchand A, Starling R, et al. The International Society of Heart and Lung Transplantation guidelines for the care of heart transplant recipients. J Heart Lung Transplant. 2010;29:914–56.

**11.** Stewart S, Winters GL, Fishbein MC, et al. Revision of the 1990 working formulation for the standardization of nomenclature in the diagnosis of heart rejection. J Heart Lung Transplant. 2005;24:1710–20.

**12.** Ackerman MJ, Priori SG, Willems S, et al. HRS/EHRA expert consensus statement on the state of genetic testing for the channelopathies and cardiomyopathies. Heart Rhythm. 2011;8:1308–39.

**KEY WORDS** SPCTPD/ACC/AAP/AHA Training Statement, clinical competence, Eisenmenger physiology, fellowship training, heart failure, heart transplantation, pediatric cardiology, pulmonary hypertension

JACC VOL. 66, NO. 6, 2015
AUGUST 11, 2015:732–9

## APPENDIX 1. AUTHOR RELATIONSHIPS WITH INDUSTRY AND OTHER ENTITIES (RELEVANT)—TASK FORCE 7: PEDIATRIC CARDIOLOGY FELLOWSHIP TRAINING IN PULMONARY HYPERTENSION, ADVANCED HEART FAILURE, AND CARDIAC TRANSPLANTATION

| Committee Member | Employment | Consultant | Speakers Bureau | Ownership/ Partnership/ Principal | Personal Research | Institutional/ Organizational or Other Financial Benefit | Expert Witness |
|---|---|---|---|---|---|---|---|
| Steven A. Webber *(Co-Chair)* | Vanderbilt University School of Medicine—James C. Overall Professor and Chair, Department of Pediatrics; Monroe Carell Jr. Children's Hospital at Vanderbilt—Pediatrician-in-Chief | None | None | None | None | None | None |
| Daphne T. Hsu *(Co-Chair)* | Albert Einstein College of Medicine—Professor of Pediatrics; Children's Hospital at Montefiore—Division Chief, Pediatric Cardiology; Co-Director, Pediatric Heart Center | None | None | None | None | None | None |
| Jeffrey A. Feinstein | Stanford University—Professor, Pediatrics and by courtesy BioEngineering; Lucile Packard Children's Hospital, Stanford—Director, Pediatric Pulmonary Hypertension Service, Dunlevie Family Chair in Pulmonary Vascular Disease | None | None | None | None | None | None |
| D. Dunbar Ivy | Children's Hospital Colorado—Director, Pediatric Pulmonary Hypertension Program; University of Colorado School of Medicine—Chief, Pediatric Cardiology; Selby's Chair of Pediatric Cardiology; Professor of Pediatrics | None | None | None | None | None | None |
| Thomas J. Kulik | Boston Children's Hospital—Senior Associate in Cardiology; Director, Pulmonary Hypertension Program, Department of Cardiology; Harvard Medical School—Associate Professor of Pediatrics | None | None | None | None | None | None |
| W. Robert Morrow | Children's Medical Center, Dallas—Executive Vice President; Chief Clinical Officer | None | None | None | None | None | None |
| Elfriede Pahl | Ann & Robert H. Lurie Children's Hospital—Medical Director, Heart Transplantation and Heart Failure; M.E. Wodika Research Chair; Northwestern Feinberg School of Medicine—Professor of Pediatrics | None | None | None | None | None | None |
| David N. Rosenthal | Lucille Packard Children's Hospital, Stanford University—Professor of Pediatrics | None | None | None | None | None | None |

For the purpose of developing a general cardiology training statement, the American College of Cardiology (ACC) determined that no relationships with industry (RWI) or other entities were relevant. This table reflects authors' employment and reporting categories. To ensure complete transparency, authors' comprehensive healthcare-related disclosure information—including RWI not pertinent to this document—is available in an online data supplement. Please refer to http://www.acc.org/guidelines/about-guidelines-and-clinical-documents/relationships-with-industry-policy for definitions of disclosure categories, relevance, or additional information about the ACC Disclosure Policy for Writing Committees.

## APPENDIX 2. PEER REVIEWER RELATIONSHIPS WITH INDUSTRY AND OTHER ENTITIES (RELEVANT)—TASK FORCE 7: PEDIATRIC CARDIOLOGY FELLOWSHIP TRAINING IN PULMONARY HYPERTENSION, ADVANCED HEART FAILURE, AND CARDIAC TRANSPLANTATION

| Name | Employment | Representation | Consultant | Speakers Bureau | Ownership/ Partnership/ Principal | Personal Research | Institutional/ Organizational or Other Financial Benefit | Expert Witness |
|---|---|---|---|---|---|---|---|---|
| Regina Lantin-Hermoso | Texas Children's Hospital | ACC ACPC Council | None | None | None | None | None | None |
| Carole Warnes | Mayo Clinic—Professor, Medicine | ACC BOT | None | None | None | None | None | None |
| Eric S. Williams | Indiana University School of Medicine—Professor (Cardiology) and Associate Dean; Indiana University Health, Cardiology Service Line Leader | ACC CMC Lead Reviewer | None | None | None | None | None | None |

For the purpose of developing a general cardiology training statement, the ACC determined that no relationships with industry or other entities were relevant. This table reflects peer reviewers' employment, representation in the review process, as well as reporting categories. Names are listed in alphabetical order within each category of review. Please refer to http://www.acc.org/guidelines/about-guidelines-and-clinical-documents/relationships-with-industry-policy for definitions of disclosure categories, relevance, or additional information about the ACC Disclosure Policy for Writing Committees.

ACC indicates American College of Cardiology; ACPC, Adult Congenital and Pediatric Cardiology; BOT, Board of Trustees; and CMC, Competency Management Committee.

JOURNAL OF THE AMERICAN COLLEGE OF CARDIOLOGY
© 2015 BY THE SOCIETY OF PEDIATRIC CARDIOLOGY TRAINING PROGRAM DIRECTORS, AMERICAN COLLEGE OF CARDIOLOGY FOUNDATION, AMERICAN ACADEMY OF PEDIATRICS, AND THE AMERICAN HEART ASSOCIATION, INC.
PUBLISHED BY ELSEVIER INC.

VOL. 66, NO. 6, 2015
ISSN 0735-1097/$36.00
http://dx.doi.org/10.1016/j.jacc.2015.03.006

TRAINING STATEMENT

# Task Force 8: Pediatric Cardiology Fellowship Training in Research and Scholarly Activity

William T. Mahle, MD, FAAP, FACC, FAHA, *Co-Chair*
Anne M. Murphy, MD, FACC, FAHA, *Co-Chair*
Jennifer S. Li, MD
Yuk M. Law, MD, FAAP
Jane W. Newburger, MD, MPH, FACC, FAHA
Stephen R. Daniels, MD, PhD
Daniel Bernstein, MD
Bradley S. Marino, MD, MPP, MSCE, FAAP, FACC, FAHA
Robert D. Ross, MD, FAAP, FACC

## 1. INTRODUCTION

### 1.1. Document Development Process

The Society of Pediatric Cardiology Training Program Directors (SPCTPD) board assembled a Steering Committee that nominated 2 chairs, 1 SPCTPD Steering Committee member, and 6 additional experts from a wide range of program sizes, geographic regions, and subspecialty focuses. Representatives from the American College of Cardiology (ACC), American Academy of Pediatrics (AAP), and American Heart Association (AHA) participated. The Steering Committee member was added to provide perspective to each Task Force as a "nonexpert" in that field. Relationships with industry and other entities were not deemed relevant to the creation of a general cardiology training statement; however, employment and affiliation information for authors and peer reviewers are provided in Appendixes 1 and 2, respectively, along with disclosure reporting categories. Comprehensive disclosure information for all authors, including relationships with industry and other entities, is available as an online supplement to this document.

The writing committee developed the document, approved it for review by individuals selected by the participating organizations (Appendix 2), and addressed their comments. The final document was approved by the SPCTPD, AAP, and AHA in February 2015 and approved by the ACC in March 2015. This document is considered current until the SPCTPD revises or withdraws it.

### 1.2. Background and Scope

There has been substantial scientific progress relevant to pediatric cardiology in the 10 years since the last training guidelines for research were published (1). The prior guidelines and a National Institutes of Health (NIH) expert panel stressed that there remains a critical need for advancement and application of new knowledge in a breadth of disciplines relevant to the field (2). These guidelines begin with the principle that there is a compelling need to train pediatric cardiology fellows to develop new knowledge and to translate research findings into practice. Because research skills are relevant to all those trained in our field, it is essential to develop both core skills and knowledge to allow the realization of meaningful research that is matched to the trainee's interests. Different pathways and training schedules must be considered to address the specific needs of each trainee with guidance from mentors. A discussion with each trainee early in fellowship may facilitate

The American College of Cardiology requests that this document be cited as follows: Mahle WT, Murphy AM, Li JS, Law YM, Newburger JW, Daniels SR, Bernstein D; Marino BS, Ross RD. Task force 8: pediatric cardiology fellowship training in research and scholarly activity. J Am Coll Cardiol 2015;66:740–7.

This article is copublished in *Circulation*.

training pathways for those interested in advanced research training. Training of pediatric cardiology fellows requires that the sponsoring division and institution have appropriate resources for training fellows in research. As noted in a prior version of these guidelines, expertise and mentorship in a variety of scientific disciplines relative to pediatric cardiology are essential.

Although sufficient resources and dedicated time are critical to success, the expertise and commitment of the mentor is 1 of the most important elements of research training (3). The training program must ensure that trainees gain experience and develop career pathways with the advice and support of appropriate mentors from throughout the institution. Just as a program needs to have sufficient clinical volume to support a trainee, so too does a fellowship require an adequate number of well-qualified, established faculty mentors to ensure a successful research training experience. Early in the training fellowship, a faculty member, usually a pediatric cardiologist with extensive experience in research, should provide an overview of the research training including a list of potential mentors.

Once a trainee has identified their mentor, the Scholarship Oversight Committee (SOC) will assist in monitoring the trainee's progress. There are several key ingredients to successful mentorship (4,5), including: 1) a sensible matching process designed to link mentor/mentee according to shared research goals; 2) jointly established and realistic expectations, including timelines that are understood clearly by both parties; 3) a written contract or agreement between the mentor/mentee that identifies key skill development needs and objectives and signifies a commitment on both parties to dedicate the time and effort required to meet the other's expectations; 4) the allocation of specific time for regular mentor/mentee meetings; 5) an ongoing evaluation/feedback process that serves both parties; and 6) respect for sex and/or ethnic differences.

In most cases, it is advantageous for the mentor to be an established researcher rather than junior faculty. An established investigator may be better able to identify pitfalls and obstacles in study design, and an associate or full professor often has more stable resources to ensure successful completion of a project. However, in some cases, young faculty may do particularly well in mentoring roles. It is recommended that when a junior faculty member is assigned as a mentor, he or she should be paired with a more senior investigator to serve as co-mentors.

### 1.3. Levels of Expertise—Core and Advanced

In this statement, we discuss core training for all fellows enrolled in a traditional 3-year pediatric cardiology fellowship and advanced training for fellows who wish to embark on a career in pediatric cardiology research. Core training is required for all trainees and is intended to ensure that fellows acquire the knowledge base and skills necessary to become a pediatric cardiologist able to conduct research and participate in scholarly activity. Advanced training guidelines are recommended for fellows who wish to commit a large part of their career to research.

## 2. PROGRAM RESOURCES AND ENVIRONMENT

### 2.1. Types of Research

For the field of pediatric cardiology to advance and address key questions in the coming decades, it is critical to carry out various types of research. Accordingly, the fellowship research programs should allow trainees to obtain structured training in a number of established or evolving disciplines. Most training programs have emphasized 3 primary avenues for research: 1) basic research in imaging sciences; molecular, cellular, and developmental biology; physiology; structural biology; genetics; genomics; proteomics; and biomarkers research; 2) patient-oriented research, including clinical trials, epidemiological studies, population-based studies, behavioral science, outcomes research, quality and safety research, biomedical ethics, medical informatics, and application of imaging technologies; and 3) translational research that bridges the gap by turning laboratory findings into new drugs, devices, or procedures, or bedside-to-bench studies that apply clinical observations to develop fundamental mechanistic studies. However, there are a number of emerging fields that may overlap with the 3 core approaches, yet increasingly require specialized skills or training. These fields include clinical cardiovascular genetics, health services studies, educational research, and health economics. By developing expertise in these fields, the next generation of pediatric cardiologists will be best equipped to address critical challenges.

### 2.2. General Expectations

The resources needed to foster a meaningful research training experience are considerable. Institutions should not underestimate the financial commitment and breadth of expertise that are needed to successfully fulfill these obligations.

### 2.3. Personnel

First and foremost, a training program needs a committed fellowship director. A fellowship director takes on many responsibilities in the fellowship program, so it may be valuable to designate a faculty member to oversee the research training. However, in some cases, the fellowship director may have the time, expertise, and interest to

direct this important endeavor. This director of fellowship research would be entrusted to assemble and monitor the SOC. The composition, structure, and function of the SOC have been defined by the American Board of Pediatrics (6). The director of fellowship research would also be responsible for assessing each trainee's progress.

### 2.4. Curriculum

The first requirement is to have a formal research education curriculum. This should be clearly defined and shared with trainees and other faculty members. The basic curriculum would include fundamental research principles such as protection of human subjects, evidence-based medicine, core biostatistics, clinical research design, and scientific writing. Many institutions have developed a core research program designed for fellows from various divisions. Such an approach is encouraged because it allows for shared expertise, collaboration, and efficient use of resources.

There should also be active research activities within cardiology and/or other groups that are involved in the care of pediatric cardiology patients. A faculty that is active in research will not only provide project opportunities and mentorship, but will also naturally bring out exchange of research ideas and reference relevant known research data in the course of patient care. The medium for scholarly exchange and interaction within cardiology should also be formal such as regularly scheduled journal clubs and research-in-progress updates. Protected time should be allotted for the trainee to attend these and other scholarly conferences and seminars.

Programs should provide the opportunity for fellows to collaborate or conduct multidisciplinary research with multiple investigators. Even if the cardiology program is active in research, a multidisciplinary approach will allow the trainee to leverage expertise from outside the division. The program director, research director, and SOC chair should assist the trainee in identifying these external resources.

### 2.5. Ancillary Staff

Critical elements of research training often include the firsthand preparation of an institutional review board submission, primary statistical analysis of research data, and grant application. The trainee needs to have knowledge of all of these areas. However, to support research endeavors, trainees engaging in complex research projects will often need assistance with data management, statistical analysis, and grant submission. A research training program should integrate with the larger divisional, departmental, or institutional research centers with access to research coordinators, biostatisticians, and grant writing assistants to ensure success for the trainees.

### 2.6. Financial Resources

Most forms of research require financial resources to ensure success. Therefore, programs will need to provide support to pediatric cardiology trainees. This financial support may come from extramural grants or endowments available to the established faculty. Training grants may provide some support. Discretionary funds and local grants may be available. Program directors need to not only provide an inquisitive research environment and passionate mentors, but also ensure that mentors can provide adequate project support to accomplish the research aims. There should also be financial support for the trainee to attend scientific meetings, and trainees should be particularly encouraged to submit and present original research at important scientific meetings.

Last, for conducting research, the training facility should have access to research administration that oversees research activities. This includes a human subject protection committee and assistance with grant proposals such as budget analysis. Free access to a library system with electronic access to most full-text articles and journals is mandatory. Additional support services may include standard computer hardware and statistical software.

### 2.7. Duration of Research Training

The Subspecialties Committee of the American Board of Pediatrics has stated that the principal goal of fellowship training should be the development of future academic pediatricians (6). To that end, it is recognized that a significant proportion (≥12 months) of the 3-year training program should be dedicated to scholarly activities and research training (6). The dedicated research time can be configured in various manners (see Section 5, Flexibility For Research Training) and should be protected time as much as possible.

For those trainees planning a career with a strong concentration in research, we recommend that the duration of research training should be considerably longer. To attain the needed skills, 24 months or more of dedicated research training should be undertaken. This will often require that the duration of fellowship training be extended beyond the 3 years.

## 3. CORE TRAINING: GOALS AND METHODS

### 3.1. Clinical Research

With appropriate mentoring, the trainee should develop skills in the following areas: literature critique, study design, funding, research implementation, and dissemination of results. For specific recommendations for each

**TABLE 1** Core Curricular Competencies for Pediatric Cardiology—Clinical Research and Scholarly Activity

**Medical Knowledge**
- Know the methods of conducting a comprehensive and systematic search of the literature on a clinical problem.
- Know the basic statistical methods used in clinical research studies.
- Know the principles of summarizing and interpreting results of published studies including identifying potential sources of bias.
- Know the strengths and weaknesses of different clinical research study designs.
- Know the principles underlying a well-defined hypothesis formation and specific goal definitions.
- Know the principles behind optimal study design for addressing a clinical research question using a protocol that identifies inclusion and exclusion criteria, outcome measures, power analysis, and data analysis.

*Evaluation Tools: reporting to and obtaining feedback from the Scholastic Oversight Committee, conference presentation, and in-training examination*

**Patient and Procedural Skills**
- Have the skills to determine the resources needed and to implement a clinical research plan.
- Have the skills to identify gaps in knowledge within a research problem.
- Have the skills to evaluate selection bias, misclassification, and confounding variables.
- Have the skills to obtain informed consent and assent for enrollment.
- Have the skills to recognize and report adverse events.

*Evaluation Tools: reporting to and obtaining feedback from the Scholastic Oversight Committee*

**Systems-Based Practice**
- Know governmental or industry standard regulatory requirements in the study design.

*Evaluation Tools: reporting to and obtaining feedback from the Scholastic Oversight Committee*

**Professionalism**
- Have the ability to identify ethical challenges and potential conflicts of interest in clinical research.

*Evaluation Tools: reporting to and obtaining feedback from the Scholastic Oversight Committee, and reflection and self-assessment*

**Interpersonal and Communication Skills**
- Have the skills to write a grant for intramural or extramural funding.
- Have the skills to prepare an abstract for submission to a national meeting.
- Have the skills to prepare a manuscript for publication.
- Have the skills to present an abstract at a national conference.

*Evaluation Tools: reporting to and obtaining feedback from the Scholastic Oversight Committee, mentor evaluation, and 360 evaluation*

Adapted from the CTSA web site (7).

of these skill domains, organized in the ACGME core competency structure, please see **Table 1**. This table is adapted from more extensive charts of clinical/translational research core competencies that can be found at the NIH Clinical and Translational Science Award (CTSA) web site (https://ctsacentral.org/wp-content/documents/CTSA%20Core%20Competencies_%20final%202011.pdf).

Familiarity with these domains requires a fundamental knowledge of basic biostatistical methods, including diagnostic test performance (sensitivity, specificity, predictive value, and receiver-operating characteristic curves) and parametric and nonparametric data analysis, including comparison of proportions, power and sample size, correlation, linear and logistic regression, and multivariable analysis. During research training, the trainee will be required to undertake a scholarly project that meets requirements for subspecialty certification by the American Board of Pediatrics. Such scholarly activity may consist of a project in which the trainee undertakes a hypothesis-driven study or a project requiring substantive scholarly exploration and analysis. The scholarly activity must include active participation by the fellow that is mentored by faculty and results in the generation of a peer-reviewed publication, critical systematic review, or meta-analysis of the literature. Core research training in the domains could be obtained as part of a master's program in clinical investigation, public health, or some other structured degree program. Competency in the skills noted in **Table 1** can be documented as part of the oversight of the trainee during his or her fellowship.

### 3.2. Laboratory/Basic and Translational Research

Although the minority of fellows pursue scholarly projects that involve laboratory-based research, these skills are important because of the broad impact of basic research on the field. A certain core knowledge base is relevant and important for a specialist in the field (7). These skills along with those for trainees who wish to pursue laboratory training are outlined in **Table 2**. A basic understanding of the genetic basis of disease and the impact on genomic variation on disease presentation is needed.

## 4. ADVANCED TRAINING: GOALS AND METHODS

Fellowship directors should communicate frequently with trainees regarding career goals. For those fellows who desire to commit a large part of their career to research, program directors should help configure the training to ensure success in this endeavor. Trainees preparing for clinical research careers in pediatric cardiology need a similar time commitment and similar advanced training as those pursuing careers in basic science research. Some trainees may have previously obtained advanced training as part of an MD/MPH or MD/PhD program in medical or postgraduate school, but

**TABLE 2 Core Curricular Competencies for Pediatric Cardiology–Basic/Translational Research and Scholarly Activity**

**Medical Knowledge**
- Know the methods of conducting a comprehensive search of the literature on the biological basis of a pediatric cardiovascular disease, syndrome, or fundamental biological question.
- Know the principles of summarizing and interpreting the impact and potential sources of conceptual or methodological flaws of published basic/translational studies.
- Know what constitutes a well-defined research hypothesis for a laboratory/translational study.
- Know what constitutes a logical research approach for addressing a basic/translational research question.
- Know the principles behind optimal experimental protocols and methods that includes a rigorous research data analysis plan, expected results, limitations, and alternative technical approaches.
- Know the process for and how to assess, analyze, and replicate data to establish support or refutation of hypotheses.

*Evaluation Tools: reporting to and obtaining feedback from the Scholastic Oversight Committee, conference presentation, and in-training examination*

**Patient and Procedural Skills***
- Have the skills to identify gaps in knowledge of the fundamental basis of a biological process, syndrome, or pediatric cardiovascular disease.
- Have the skills to accurately record and store research records.
- Have the skills to determine the resources needed and to implement a laboratory research plan.
- Have the skills to apply appropriate statistical analyses to laboratory data.

*Evaluation Tools: reporting to and obtaining feedback from the Scholastic Oversight Committee, and in-training examination*

**Systems-Based Practice***
- Incorporate regulatory precepts into the execution of any laboratory study.

*Evaluation Tools: reporting to and obtaining feedback from the Scholastic Oversight Committee*

**Practice-Based Learning and Improvement***
- Acquire requisite training and technical skills for experimental work, including all institutional review board requirements.

*Evaluation Tools: reporting to and obtaining feedback from the Scholastic Oversight Committee, mentor evaluations, and 360 evaluations*

Note: other sections listed under clinical research such as Professionalism and Interpersonal and Communication Skills should be applied to those undertaking basic/translational research.
*Competency required only for those undertaking translational and/or basic research. Adapted from the CTSA web site (7).

may need to develop specific skills for basic or clinical cardiovascular research. Others may need advanced training, including coursework in epidemiology, study design, and biostatistics. This may be obtained as part of an advanced degree program or as part of a separate career development plan. Advanced research training for clinical research should also include mentored investigational experience with an active and productive scientist working in an appropriate field, such as epidemiology, population science, behavioral science, quality and safety of care, or outcomes research. Often it is appropriate to assemble a mentoring team, which can provide a range of expertise and is directed by a senior mentor.

For trainees seeking careers with a major emphasis on basic or laboratory research, additional focused training will be needed. There will be a wide variation in skills that trainees bring in based on previous training and experience. For those with minimal or no prior laboratory training, the need for didactic course work is greater, as is a more prolonged training experience. Formal entry into a PhD training program may be considered.

There are often institutional or individual research training grants (T32, F32) to support the research training and career development, including coursework and mentored research training. The NIH Loan Repayment Grant can help support the focused early investigator.

The advanced research training should be viewed as only the beginning of the training experience. Individuals who pursue this path will need counseling on finding academic positions, protected time, and resources required to support the development of meaningful research projects.

## 5. FLEXIBILITY FOR RESEARCH TRAINING

Fellowship research training should allow significant flexibility to accommodate diverse career paths. For some trainees, consecutive months of dedicated research training may provide the best environment for growth. However, for others, it may be best to alternate some periods of clinical training with dedicated research time. This may be valuable, for example, when planning a clinical investigation that requires several distinct phases such as protocol development, institutional review board submission, and recruitment/enrollment. This approach may be necessary when trying to integrate structured course work from the academic calendar year into the training program. This may be especially relevant for those who obtain a concomitant master's level training degree (such as in epidemiology or public health). Meeting the demands of both clinical and research training poses a great challenge to any training program; thus, the time devoted to research should be assigned to allow the trainee the best opportunity for success. The breadth of training opportunities must allow fellows the flexibility to configure their research training in ways that best meet individual career goals. Fellows should be allowed to work with program directors to design their schedule and commitments to foster time management skills and career planning that will be critical in their early career.

## 6. EVALUATION AND DOCUMENTATION

Ongoing evaluation of progress in advanced research training is important. Inherent within the tables for core training are basic tasks that must be accomplished for successful completion of the research portion of fellowship. Overall evaluation should include specific goal setting and review of progress made on those goals. Research knowledge, skills, and commitment should include both objective components, such as skills and knowledge in analyzing literature and appropriately applying statistical tests, and subjective components, such as creativity, drive, and problem solving. This evaluation should be based on criteria that have been developed and agreed upon by the trainee, the SOC, and the mentoring team. The competence and accomplishments should be clearly documented at the completion of training. This evaluation should include the success of the trainee as indicated in producing a meaningful scholarly work product that hopefully results in at least 1 publication.

## SUMMARY

Research training represents a critical component of the pediatric cardiology fellowship training. To successfully carry out the mission of training, academic pediatric cardiologist programs must provide a structured research experience lead by dedicated mentors. There are a number of varied, yet fulfilling, pathways to pursue in research, and trainees should tailor the research training experience to meet their career goals.

## REFERENCES

**1.** Benson DW Jr., Baldwin HS, Mahoney LT, et al. ACCF/AHA/AAP recommendations for training in pediatric cardiology. Task force 7: training guidelines for research in pediatric cardiology. J Am Coll Cardiol. 2005;46:1401–3.

**2.** Lenfant C. Report of the Task Force on Research in Pediatric Cardiovascular Disease. Circulation. 2002;106:1037–42.

**3.** Reynolds HY. In choosing a research health career, mentoring is essential. Lung. 2008;186:1–6.

**4.** Making the Right Moves. A Practical Guide to Scientific Managment for Postdocs and New Faculty. Burroughs Wellcome Fund and Howard Hughes Medical Institute. Available at: http://www.hhmi.org/sites/default/files/Educational%20Materials/Lab%20Management/Making%20the%20Right%20Moves/moves2_ch5.pdf. Accessed April 13, 2015.

**5.** National Institutes of Health. A guide to training and mentoring in the intramural research program at NIH. Last update 2014. Available at: https://oir.nih.gov/sites/default/files/uploads/sourcebook/documents/mentoring/guide-training_and_mentoring-10-08.pdf. Accessed April 13, 2015.

**6.** The American Board of Pediatrics: Training requirements for subspecialty certification. Last update 2014. Available at: https://www.abp.org/abpwebsite/publicat/trainingrequirements.pdf. Accessed September 14, 2014.

**7.** CTSA core competencies in clinical and translational research. Last update 2012. Available at: https://ctsacentral.org/wp-content/documents/CTSA%20Core%20Competencies_%20final%202011.pdf. Accessed September 14, 2014.

**KEY WORDS** SPCTPD/ACC/AAP/AHA Training Statement, basic research, biostatistics, clinical research, epidemiology, fellowship training, pediatric cardiology

## APPENDIX 1. AUTHOR RELATIONSHIPS WITH INDUSTRY AND OTHER ENTITIES (RELEVANT)—TASK FORCE 8: PEDIATRIC CARDIOLOGY FELLOWSHIP TRAINING IN RESEARCH AND SCHOLARLY ACTIVITY

| Committee Member | Employment | Consultant | Speakers Bureau | Ownership/ Partnership/ Principal | Personal Research | Institutional/ Organizational or Other Financial Benefit | Expert Witness |
|---|---|---|---|---|---|---|---|
| William T. Mahle *(Co-Chair)* | Sibley Heart Center at Children's Healthcare of Atlanta—Medical Director, Heart Transplant and Medical Director, Clinical Research; Emory University School of Medicine—Marcus Professor of Pediatrics | None | None | None | None | None | None |
| Anne M. Murphy *(Co-Chair)* | Johns Hopkins University School of Medicine—Professor of Pediatrics, Division of Cardiology and Fellowship Program Director | None | None | None | None | None | None |
| Daniel Bernstein | Lucile Packard Children's Hospital at Stanford, Stanford University—Alfred Woodley Salter and Mabel G. Salter Professor of Pediatrics | None | None | None | None | None | None |
| Stephen R. Daniels | University of Colorado School of Medicine—Professor and Chair, Department of Pediatrics; Children's Hospital Colorado—Pediatrician-in-Chief and L. Joseph Butterfield Chair in Pediatrics | None | None | None | None | None | None |
| Yuk M. Law | University of Washington—Professor; Seattle Children's Hospital—Medical Director of Heart Failure and Transplant | None | None | None | None | None | None |
| Jennifer S. Li | Duke University—Beverly C. Morgan Professor of Pediatrics and Division Chief, Pediatric Cardiology | None | None | None | None | None | None |
| Bradley S. Marino | Northwestern University Feinberg School of Medicine—Professor Pediatrics; Professor Medical Social Sciences; Director, Cardiovascular Bridge Programs; Co-Director, Research and Academic Affairs; and Attending Physician, Cardiac Care Unit and Neonatal and Cardiac Intensive Care Follow-up Clinic; Ann and Robert H. Lurie Children's Hospital of Chicago; Northwestern Memorial Hospital | None | None | None | None | None | None |
| Jane W. Newburger | Boston Children's Hospital—Associate Cardiologist-in-Chief for Academic Affairs, Department of Cardiology; Harvard Medical School—Commonwealth Professor of Pediatrics | None | None | None | None | None | None |
| Robert D. Ross | Children's Hospital of Michigan, Wayne State University School of Medicine—Director of Fellowship Programs and The Pulmonary Hypertension Program | None | None | None | None | None | None |

For the purpose of developing a general cardiology training statement, the American College of Cardiology (ACC) determined that no relationships with industry (RWI) or other entities were relevant. This table reflects author's employment and reporting categories. To ensure complete transparency, authors' comprehensive healthcare-related disclosure information—including RWI not pertinent to this document—is available in an online data supplement. Please refer to http://www.acc.org/guidelines/about-guidelines-and-clinical-documents/relationships-with-industry-policy for definitions of disclosure categories, relevance, or additional information about the ACC Disclosure Policy for Writing Committees.

## APPENDIX 2. PEER REVIEWER RELATIONSHIPS WITH INDUSTRY AND OTHER ENTITIES (RELEVANT)—TASK FORCE 8: PEDIATRIC CARDIOLOGY FELLOWSHIP TRAINING IN RESEARCH AND SCHOLARLY ACTIVITY

| Name | Employment | Representation | Consultant | Speakers Bureau | Ownership/ Partnership/ Principal | Personal Research | Institutional/ Organizational or Other Financial Benefit | Expert Witness |
|---|---|---|---|---|---|---|---|---|
| Bruce Gelb | Mount Sinai Medical Center—Professor, Pediatrics | AHA | None | None | None | None | None | None |
| Regina Lantin-Hermoso | Texas Children's Hospital | ACPC Council | None | None | None | None | None | None |
| Carole Warnes | Mayo Clinic—Professor, Medicine | ACC BOT | None | None | None | None | None | None |
| Eric Williams | Indiana University School of Medicine—Professor (Cardiology) and Associate Dean; Indiana University Health, Cardiology Service Line Leader | ACC CMC Lead Reviewer | None | None | None | None | None | None |

For the purpose of developing a general cardiology training statement, the ACC determined that no relationships with industry or other entities were relevant. This table reflects peer reviewers' employment, representation in the review process, as well as reporting categories. Names are listed in alphabetical order within each category of review. Please refer to http://www.acc.org/guidelines/about-guidelines-and-clinical-documents/relationships-with-industry-policy for definitions of disclosure categories, relevance, or additional information about the ACC Disclosure Policy for Writing Committees.

ACC indicates American College of Cardiology; ACPC, Adult Congenital and Pediatric Cardiology; AHA, American Heart Association; BOT, Board of Trustees; and CMC, Competency Management Committee.