

Task Force 5: Pediatric Cardiology Fellowship Training in Critical Care Cardiology¹

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Pediatric Training Statement: Critical Care Cardiology

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Endorsed by the Pediatric Cardiac Intensive Care Society

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1. Introduction

1.1. Document Development Process

The Society of Pediatric Cardiology Training Program Directors (SPCTPD) board assembled a steering committee which nominated 2 chairs, 1 SPCTPD steering committee member, and 6 additional members from a wide range of program sizes, geographic regions, and subspecialty focus. 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 “non-expert” 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 Appendices 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

(http://jaccjacc.acc.org/Clinical_Document/Ped_TS_TF5_Comprehensive_RWI_Supplement.pdf).

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

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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

In order 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 pharmacologic agents on cardiac physiology, and function as an effective communicator within a multidisciplinary team. The experience garnered by a pediatric cardiology trainee in the pediatric cardiac intensive care unit (CICU) 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. through 3.2.6) and have added to some of the Specific Training Goals (Sections 3.3.1 through 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 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

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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 stand-alone pediatric cardiac ICUs (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 assure 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. While 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 cardiac ICU setting over the course of the general cardiology fellowship. It is also important to note that these defined experiences require

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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.

3.2. General Competencies

Through training and upon completion of a fellowship, the pediatric cardiology trainee is expected to demonstrate incremental proficiency in the skillsets 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 exam findings, assess the patient's history and laboratory data, and determine if 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. Secondly, 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 team, interventional catheterization team, and surgical team). He/she should provide ongoing input regarding physical examination, laboratory, and diagnostic study interpretation at the request of the managing clinical service(s).

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.

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- 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, in-training exam*

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, 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, 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, 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, reflect and self-assessment

Professionalism

- Conduct oneself in a respectful and collegial manner.

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

Interpersonal and Communication Skills

- Effectively communicate with multiple teams involved in complex patient care.
- Provide non-biased 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, 360 evaluations

ICU indicates intensive care unit.

Additional information on general competencies is included below.

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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 ascertaining 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 intra-hospital 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 anatomical investigation and determine 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)

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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 due to infectious endocarditis/sepsis and inflammatory (non-infectious) 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 non-cardiac surgery. The fellow should be capable of accurately relaying the cardiovascular physiologic 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 pharmacologic and other therapies for patients with single ventricle physiology.

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- Provide consultation regarding therapies for patients with high pulmonary vascular resistance and pulmonary hypertension.

3.2.5. Function as a Member of a Multidisciplinary Team Demonstrating Professionalism and Excellent Communication Skills

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

- Provide non-biased 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.
- Understanding the general principles for providing effective and compassionate "end-of-life" and palliative care.
- 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.

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- 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, neurologic 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, neurologic dysfunction (due to 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 pre- and post-operative 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 post-angiography).
- Understanding the major medical concerns related to older adolescents and young adults.
- Understanding the implications of genetic conditions and syndromes and implication for care.

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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 pharmacologic 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 E₁
- Neuromuscular blocking agents (e.g., pancuronium, vecuronium, rocuronium, succinylcholine)
- Analgesics and sedatives (e.g., opiates, ketamine, benzodiazepines, dexmedetomidine)
- The cardiovascular effects of commonly-used general anesthetics; risks and benefits
- 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

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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 E₁ 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 and Therapy of Arrhythmias

While 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 the 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

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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. In 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 exam 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).
- 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 O₂ 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 which 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 the 2014 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.

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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 above 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.

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 which 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 pharmacologic 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, in-training exam

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.†

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- 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 pharmacologic 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 hemi-diaphragm(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 pre- and post-operative 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, 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, 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, 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; OHT, orthotopic heart transplant; VA ECMO, venoarterial extracorporeal membrane oxygenation; and VAD, ventricular assist device.

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

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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 towards whether the fellow met those pre-specified 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 their 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.

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Committee Member	Employment	Consultant	Speakers Bureau	Ownership/ Partnership/ Principal	Personal Research	Institutional/ Organizational or Other Financial Benefit	Expert Witness
Timothy F. Feldes (<i>Co-Chair</i>)	Nationwide Children's Hospital, The Ohio State University—Chief, Pediatric Cardiology; Professor of Pediatrics	None	None	None	None	None	None
Stephen J. Roth (<i>Co-Chair</i>)	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

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Committee Member	Employment	Consultant	Speakers Bureau	Ownership/ Partnership/ Principal	Personal Research	Institutional/ Organizational or Other Financial Benefit	Expert Witness
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 ACC determined that no relationships with industry 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 (http://jaccjacc.acc.org/Clinical_Document/Ped_TS_TF5_Comprehensive_RWI_Supplement.pdf). 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.

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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; and CMC, Competency Management Committee.

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