2017 ACC/AHA/HFSA/ISHLT/ACP Advanced Training Statement on Advanced Heart Failure and Transplant Cardiology (Revision of the ACCF/AHA/ACP/HFSA/ISHLT 2010 Clinical Competence Statement on Management of Patients With Advanced Heart Failure and Cardiac Transplant)

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A Report of the ACC Competency Management Committee

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Preamble

Since the 1995 publication of its Core Cardiovascular Training Statement (COCATS)(1), the American College of Cardiology (ACC) has played a central role in defining the knowledge, experiences, skills, and behaviors expected of all clinical cardiologists upon completion of training. Subsequent updates have incorporated major advances and revisions—both in content and structure—including, most recently, a further move toward competency (outcomes)-based training, and the use of the 6 domain competency structure promulgated by the Accreditation Council for Graduate Medical Education (ACGME) and the American Board of Medical Specialties, and endorsed by the American Board of Internal Medicine (ABIM). A similar structure has been used by ACC to describe the aligned general cardiology lifelong learning competencies that all practicing cardiologists are expected to maintain. Many hospital systems also now use the 6-domain structure as part of medical staff privileging and peer-review professional competence assessments.

Whereas COCATS has focused on general clinical cardiology, ACC Advanced Training Statements define selected competencies that go beyond those expected of all cardiologists and require training beyond a standard 3-year cardiovascular disease fellowship. This includes sub-subspecialties for which there is an ABIM added-qualification designation, such as advanced heart failure and transplant cardiology (AHFTC). The Advanced Training Statements also describe key experiences and outcomes necessary to maintain or expand competencies during practice, though over time, these will be supplemented by additional lifelong learning statements that address the commitment to sustaining and enriching competency over the span of a career.

The ACC Competency Management Committee oversees the development and periodic revision of the cardiovascular training and competency statements. A key feature of competency-based training and performance is an outcome-based evaluation system. Although specific areas of training may require a minimum number of procedures, or duration of training time, to assure adequate exposure to the range of clinical disorders, and to effectively evaluate the trainee, it is the objective assessment of proficiency and outcomes that demonstrates the trainee's achievement of competency. Evaluation tools may include in-training examinations, direct observation, procedure logbooks, simulation, conference presentations, and multisource (360˚) evaluations, among others. For practicing physicians, these tools may also include professional society registry or hospital quality data, peer-review processes, and patient satisfaction surveys. A second feature of a competency-based training program is the recognition that learners develop some competency components at different rates. For multiyear training programs, assessment of selected representative curricular milestones during training can identify learners or areas that require additional focused attention.

The recommendations in the ACC cardiovascular training statements are based on available evidence and, where evidence is lacking, reflect expert opinion. The writing committees are broad-based, and typically include content experts, general cardiology and sub-subspecialty training directors, practicing cardiologists, and early-career representatives. All documents go through a rigorous process of peer-review and public comment. Recommendations are intended to guide the assessment of competence of cardiovascular care providers beginning independent practice as well as those undergoing periodic review to help assure that competence is maintained.

This Advanced Training Statement addresses the added competencies required of sub-subspecialists in AHFTC for diagnosis and management at a high level of skill of patients with advanced heart failure who may also undergo placement of mechanical circulatory support devices or cardiac transplantation. It is intended to complement the basic training in heart failure required of all trainees during the standard 3-year cardiovascular fellowship. The training requirements and designated clinical competencies in this report focus on the core competencies reasonably expected of all AHFTC specialists. It also identifies some aspects of AHFTC that go beyond the core expectations and that may be achieved by some AHFTC specialists based on career focus, either during or following formal AHFTC fellowship training.

The work of the Writing Committee was supported exclusively by the ACC without commercial support. Writing Committee members volunteered their time to this effort. Conference calls of the writing committee were confidential and attended only by committee members. To avoid actual, potential, or perceived conflict of interest arising as a result of relationships with industry (RWI) or other entities of members of the Writing Committee or peer reviewers of the document, each individual is required to disclose all current healthcare-related relationships, including those existing 12 months before initiation of the writing effort. The ACC Competency Management Committee reviewed these disclosures to identify products (marketed or under development) pertinent to the document topic. Based on this information, the Writing Committee was selected to assure that the Chair and a majority of members have no relevant RWI. Authors with relevant RWI were not permitted to draft initial text or vote on recommendations or curricular requirements to which their RWI might apply. RWI was reviewed at the start of all meetings and conference calls and updated as changes occurred. Relevant RWI for authors is disclosed in Appendix 1. To ensure transparency, comprehensive RWI for authors, including RWI not pertinent to this document, is posted online at http://jaccjacc.acc.org/Clinical_Document/AHFTC_ATS_Author_Comprehensive_Disclosure_Table.pdf. Peer reviewers, along with their employment information and affiliation in the review process, are shown in Appendix 2. There are no RWI restrictions for participation in peer review, promoting the opportunity for comment on the document from a variety of constituencies/viewpoints to inform final document

content. However, all reviewers must disclose all healthcare-related RWI and other entities to participate in the review process and their disclosure information is posted online at http://jaccjacc.acc.org/Clinical_Document/AHFTC_ATS_Peer_Reviewer_Comprehensive_Disclosure_Table.pdf. Disclosure information for the ACC Competency Management Committee is also available online at http://www.acc.org/guidelines/about-guidelines-and-clinical-documents/guidelines-and-documents-task-forces, as well as the ACC disclosure policy for document development at http://www.acc.org/guidelines/about-guidelines-and-clinical-documents/relationships-with-industry-policy.

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1. Introduction

1.1. Document Development Process

1.1.1. Writing Committee Organization

The writing committee consisted of a broad range of members representing ACC, the American Heart Association (AHA), and the Heart Failure Society of America (HFSA), the International Society for Heart & Lung Transplantation (ISHLT) and the American College of Physicians (ACP), identified because they perform ≥1 of the following roles: cardiovascular training program directors; AHFTC training program directors; early-career experts through mid- and later-career experts; general cardiologists; AHFTC specialists representing both the academic and community-based practice settings as well as small, medium, and large institutions; specialists in all aspects of AHFTC, including mechanical circulatory support (MCS), cardiac resynchronization therapy, and pulmonary arterial hypertension; specialists in cardiothoracic surgery, critical care cardiology, electrophysiology, and adult congenital heart disease; physicians experienced in training and working with the ACGME/Residency Review Committee as well as the ABIM Cardiovascular Board and Competency Committee; physicians experienced in defining and applying training standards according to the 6 general competency domains promulgated by the ACGME and the American Board of Medical Specialties and endorsed by the ABIM; and advanced practice nurses. This writing committee met the College's disclosure requirements for relationships with industry as described in the Preamble.

1.1.2. Document Development and Approval

The writing committee convened by conference call and email to finalize the document outline, develop the initial draft, revise the draft based on committee feedback, and ultimately approve the document for external peer review.

The document was reviewed by 11 official representatives from the ACC, AHA, HFSA, ISHLT, and ACP, as well as by 35 additional content reviewers, including AHFTC training program directors (see Appendix 2). The document was simultaneously posted for public comment from November 1, 2016 to November 18, 2016, resulting in comments from 6 additional reviewers. A total of 445 comments were submitted on the document. All comments were reviewed and addressed by the writing committee. A member of the ACC Competency Management Committee served as lead reviewer to ensure a fair and balanced peer review resolution process. Both the writing committee and the ACC Competency Management Committee approved the final document to be sent for organizational approval. The ACC, AHA, HFSA, ISHLT, and ACP approved the document for publication. This document is considered current until the ACC Competency Management Committee revises or withdraws it from publication.

1.2. Background and Scope

The original 1995 American College of Cardiology recommendations for training in adult cardiology evolved from a Core Cardiology Training Symposium (1). After several iterations, COCATS 4 focuses on trainee outcomes that require delineation of specific components of competency within the subspecialty, definition of the tools necessary to assess training, and establishment of milestones documenting the trainee's progression toward independent competency (2). Ultimately, the goal is for the trainee to develop the professional skill set to be able to evaluate, diagnose, and treat patients with acute and chronic cardiovascular disturbances.

Each COCATS 4 document includes individual Task Force reports that address subspecialty areas in cardiology, each of which is an important component in training a fellow in cardiovascular disease. Task Force 12 of that document addresses training in heart failure and updated previous standards for general cardiovascular training for fellows enrolled in cardiovascular fellowship programs (3). It addresses faculty, facilities, equipment, and ancillary support. It also addresses training components, including didactic, clinical, and hands-on experience, and the number of procedures and duration of training. Importantly, the COCATS 4 Task Force 12 report did not provide specific guidelines for AHFTC training.

This document focuses on training requirements for cardiologists seeking additional training in AHFTC, a subspecialty of adult cardiology. For training standards related to pediatric HF, readers should

refer to the SPCTPD/ACC/AAP/AHA Training Guidelines for Pediatric Cardiology Fellowship Programs Task Force 7: Pediatric Cardiology Fellowship Training in Pulmonary Hypertension, Advanced Heart Failure, and Transplantation (4).

1.2.1. Evolution of AHFTC

In 2008, the American Board of Medical Specialties approved a proposal by the ABIM to recognize the secondary subspecialty of AHFTC. The ACGME approved the training program requirements for AHFTC, effective in 2013. These actions acknowledged the special competencies, knowledge and skills required to care for patients with advanced heart failure, including the possible use of ventricular assist devices or cardiac transplantation. Over subsequent years, an increasing number of cardiologists have chosen to focus their research and/or clinical practice in this area.

The ABIM requires 3 years of cardiology fellowship training before fellows may sit for the certification examination in cardiovascular medicine. Cardiologists seeking additional certification in AHFTC must complete a 4th year of training that provides focused experience with a variety of heart failure patients and procedures, as outlined below.

1.2.2. Levels of Training

COCATS 4 updated standards for training fellows in cardiovascular medicine and established consistent training criteria across all aspects of general cardiology, including heart failure (3). For the cardiovascular fellowship, the following 3 levels of training are delineated for training in heart failure.

Level I training, the basic training required of trainees to become competent consultant cardiologists, is required of all fellows in cardiology, and can be accomplished as part of a standard 3-year training program in general cardiology.

Level II training, also described in COCATS 4, refers to additional training that enables some cardiologists to perform or interpret specific procedures or render more specialized care for patients with certain conditions. Level II training in selected areas may be achieved by some trainees during the standard 3-year cardiovascular fellowship, depending on their career goals and use of elective rotations. In the case of heart failure, Level II training is intended for individuals seeking expertise in caring for heart failure patients, particularly those with more advanced and challenging syndromes. Level II emphasizes more detailed hemodynamic assessment of these patients and focuses on transitions of care for patients with heart failure as well as the systems of care necessary to avoid hospital admission or re-admission. Level II training also prepares individuals to perform initial screening of patients cared for at

non-transplant/non-durable MCS facilities for advanced therapies, in collaboration with Level III–trained experts at advanced therapy sites.

Level III training, the primary focus of this document, requires training and experience beyond the cardiovascular fellowship for the acquisition of specialized knowledge and competency to render advanced care for patients with specific conditions. Level III training is required of individuals seeking subspecialty board certification in AHFTC. Trainees in AHFTC are expected to have completed 3 years of a cardiovascular fellowship and achieved Level I competency as described in the ACC's Core Cardiovascular Training Statement (2) and the COCATS 4 Task Force 12 report (3) before beginning the AHFTC fellowship. Level II training may be completed prior to or in conjunction with Level III training.

1.2.3. Methods for Determining Procedural Numbers

The recommended number of procedures performed and interpreted by trainees under faculty supervision has been developed on the basis of the experience and opinions of the members of the writing group and previously published competency statements, COCATS documents, and policies of the ACGME, ABIM, and United Network for Organ Sharing (UNOS). In addition, the writing committee surveyed AHFTC training program directors for additional insight into procedural volumes. Of 69 directors of ABIM–recognized training programs, 21 responded. The procedural volumes and number of technical experiences suggested in this document were considered the minimum necessary to expose trainees to a sufficient range and complexity of clinical material and allow supervising faculty to evaluate the competency of each trainee. These procedural numbers (see Section 4.2) are intended as general guidance, based on the needs and progress of typical AHFTC trainees in typical programs. Those considering these thresholds should bear in mind the fundamental nature of educational milestones — that proficiency and outcomes, rather than length of exposure or the exact number of procedures performed, are the dominant requirements. Flexibility is inherent to this concept, and the ACGME mandates that all programs establish milestones for the acquisition of various competencies by trainees during the course of fellowship training.

2. General Standards

2.1. Faculty

Engaged faculty committed to teaching are critical to the success of an AHFTC training program. Faculty must include specialists with broad knowledge of and experience in advanced heart failure, including advanced therapies and end-of-life care; management of patients with temporary and durable MCS devices and their complications; and care of heart transplant recipients, including management of acute

and long-term complications. The most recent ACGME Program Requirements for Graduate Medical Education in AHFTC require a single designated program director and at least 1 additional key clinical faculty member for every 1.5 fellows (5). Each of the key clinical faculty members should be currently certified in AHFTC by the ABIM and be able to dedicate, on average, 10 hours per week throughout the year to the educational program. In addition to developing, implementing, supervising, mentoring and evaluating the fellows' clinical and research education, at least 50% of key clinical faculty members must also demonstrate productivity in scholarship, specifically, peer-reviewed funding and/or publication of original research, reviews, editorials, case reports or textbook chapters.

2.2. Facilities

Required facilities include designated areas for outpatient and inpatient care of patients with heart failure. Inpatient facilities must provide a safe and effective environment for optimal management of patients with heart failure of varying severity, ranging from mild decompensation to refractory cardiogenic shock. A safe and sterile catheterization laboratory is necessary to provide instruction in right heart catheterization and endomyocardial biopsy. Trainees should have access to operating rooms and staff to enable observation of ventricular assist device implants, heart procurements, and transplant surgeries. Trainees should have access to outpatient facilities supported by dedicated nursing staff providing exposure to coordinated longitudinal management of patients with chronic heart failure as well as training in the consultative aspects of outpatient heart failure cardiology. There should be an established system to promote effective transitions of care that assures open communication between caregivers in the outpatient and inpatient settings. Access to a HLA laboratory should be provided. Appropriate space for didactic conferences should be available. Quality and safety initiatives should be in place to assess quality of care and clinical outcomes longitudinally across inpatient and outpatient arenas throughout the healthcare system.

2.3. Equipment

Cardiopulmonary exercise stress testing equipment is necessary for education in the performance and interpretation of this crucial modality in patients with heart failure. Additional technology that aids in the diagnosis, risk stratification, and management of patients with heart failure, such as echocardiography, transesophageal echocardiography, computed tomography, magnetic resonance imaging, positron emission tomography, invasive angiography, and electrophysiology facilities should be available. Equipment for interrogation of implantable electronic devices, including cardiac resynchronization therapy (CRT) and implantable cardioverter-defibrillators (ICD) should be available for both inpatients and outpatients. Trainees should have access to catheterization laboratories equipped with both

thermodilution and Fick-based modalities for measuring cardiac output. Equipment for management and interrogation of durable MCS devices (e.g., Heartmate, HeartWare, or Total Artificial Heart) should be available so trainees gain proficiency in their use. When institutionally available, temporary, nondurable MCS devices including but not limited to intra-aortic balloon pump, TandemHeart, Impella devices, and/or extracorporeal membrane oxygenation should be accessible to trainees. It is not expected that each institution will have all of these devices, but every center should have some. At all facilities, resuscitation equipment must be readily accessible.

2.4. Ancillary Support

Level III trainees should communicate with ancillary personnel to assure comprehensive, evidence-based care. Critical to success is collaborative interaction with various physicians from within cardiology including interventionalists, advanced imaging specialists, electrophysiologists, congenital heart disease specialists, and other fields of general medical and surgical practice to address and treat the multiple comorbidities often seen in heart failure patients. Key specialties include but are not limited to cardiac and transplant surgeons, palliative care practitioners, infectious disease specialists, gastroenterologists, hepatologists, nephrologists, pulmonologists, pulmonary hypertension specialists, and experts in sleep medicine. In addition, communication with primary care physicians, geriatricians, obstetricians, endocrinologists, and oncologists is important for specific patient populations. Also essential is interaction with vital healthcare professionals including nurse practitioners and physician assistants, nurses, pharmacists, dieticians, physical and occupational therapists, and social workers.

3. Training Components

3.1. Didactic Program

Didactic instruction may take place in a variety of formats, including lectures, journal clubs, grand rounds, clinical case presentations, research conferences, simulator-based training, and patient safety or quality improvement conferences. Discussions should focus on heart failure, pulmonary hypertension, MCS, and heart transplantation and the medical knowledge items outlined in Table 1. Case conferences in particular will allow AHFTC trainees opportunities to reflect on and learn from complex cases, generate ideas for stabilizing or improving patients' health status and systems of care, and develop skills as team leaders and educators. Journal clubs bring advances in the field to trainees and provide opportunities to critically review published literature, including assessments of validity and generalizability. Neither the most recent ACGME Program Requirements for Graduate Medical Education in AHFTC (5) nor the COCATS 4 Heart Failure report (3) specifies the frequency of didactic instruction, but weekly didactic

sessions is a reasonable goal. Moreover, training programs should emphasize to AHFTC trainees the importance of lifelong learning that does not end upon completion of fellowship. For example, trainees should develop the ability to incorporate new therapies and technologies into practice.

3.2. Clinical Experience

Level III training in advanced heart failure requires rigorous clinical experiences in both the outpatient and inpatient settings, including the intensive care unit. In each clinical setting, trainees should participate in supervised patient care and act as a first-line consultant for a portion of the training period with appropriate and timely backup from attending AHFTC physicians. In this capacity, Level III trainees are expected to gather accurate, essential information from all sources, including medical interviews and record review, physical examination, cardiac device interrogation, and diagnostic procedures, including echocardiograms and hemodynamic evaluations. In addition, trainees should issue informed recommendations about preventive, diagnostic, therapeutic, and palliative options and interventions on the basis of clinical judgment, scientific evidence, and patient preferences, developing, negotiating, and implementing patient management plans. Further, they should develop the skills necessary to competently perform the diagnostic and therapeutic procedures considered essential to the management of patients with advanced heart failure, including those undergoing MCS or cardiac transplantation. Training programs must provide access to a patient population of sufficient size and diversity to nurture these competencies. Multidisciplinary meetings, including participation in the transplant selection committee, are important parts of the trainee's clinical experience.

3.3. Hands-On Procedural Experience

Hands-on experience is required for successful training and trainees should be exposed to the full spectrum of AHFTC procedures. Level III training in AHFTC requires competence in right heart catheterization and endomyocardial biopsy, acquired through experiences in the catheterization laboratory. Troubleshooting of right heart catheters in the intensive care unit provides additional expertise in the use of invasive hemodynamic monitoring, including recognition of artifact. Review of endomyocardial biopsy specimens with pathologists facilitates skill in the assessment of rejection. AHFTC trainees must become familiar with the programming and interpretation of data stored in ICD and CRT devices, which can be acquired by device interrogation. Experience in the indications and management of MCS devices providing temporary hemodynamic support of critically ill patients with heart failure is essential, recognizing that criteria for selection of specific devices may vary. AHFTC training includes exposure to implantation, interrogation, and adjustment of durable ventricular assist devices under echocardiographic guidance. Supervision of cardiopulmonary stress tests promotes

expertise in this modality. Training should also include end-of-life discussions, shared decision making, and communication with patients about advance care planning. Depending upon institutional capabilities and trainee interest, additional procedural experiences may include implantation and/or monitoring of pulmonary artery sensors, invasive assessment of patients with adult congenital heart disease, performance and interpretation of the results of pulmonary vasodilator challenges, assessment of exercise hemodynamics, or implantation of temporary MCS devices. The numbers of procedures that should be completed during the 12 months of AHFTC are summarized in Section 4.2 and the approach to evaluation of competency is in Section 5.

The field of advanced heart failure is rapidly evolving with the introduction of new technologies. While specific training requirements cannot be provided for all of these, Level III AHFTC trainees who intend to perform these procedures are expected to undergo the same training as required for faculty members performing them.

3.4. Diagnosis and Management of Emergencies and Complications

All trainees should be certified in Advanced Cardiovascular Life Support (ACLS) and well versed in the recognition and management of complications and emergencies encountered in the advanced heart failure population. Examples include cardiogenic shock such as INTERMACS (The Interagency Registry for Mechanically Assisted Circulatory Support) 1 patients, life-threatening arrhythmias such as ventricular tachycardia storm and complete heart block, severe cardiac complications in pregnant patients, respiratory failure in patients with heart failure and concomitant pulmonary illness, severe rejection with allograft failure, or life-threatening infection in immunosuppressed transplant recipients. Complications of endomyocardial biopsy and pulmonary artery catheterization should be recognized and managed, with emphasis upon knowing when to seek assistance from an interventional cardiologist or cardiothoracic surgeon in such circumstances as cardiac perforation or pericardial tamponade. Trainees should be taught to recognize and initiate management for complications of MCS devices, including thrombosis, stroke, infection, bleeding, and pump malfunction. They should be familiar with advanced life support in patients receiving mechanical support (6). All such complications should be documented and reported in accordance with institutional requirements and reviewed at patient safety or quality improvement conferences.

3.5. Diagnosis and Management of Less Common Clinical Conditions and Syndromes

Level III trainees should become familiar with less common conditions associated with heart failure symptoms. These include myocardial non-compaction, hypertrophic cardiomyopathy, cardiac amyloidosis, muscular dystrophy, arrhythmogenic right ventricular cardiomyopathy, glycogen storage disease, congenital heart defects, sarcoidosis, hemochromatosis, pulmonary artery hypertension, as well as other infectious, nutritional, and autoimmune conditions. Several uncommon inflammatory conditions have the potential to cause cardiomyopathy and heart failure, including fulminant giant cell myocarditis and acute hypersensitivity myocarditis. Metabolic or endocrine disorders such as pheochromocytoma and acromegaly can lead to cardiomyopathy and heart failure. Other less common conditions presenting as heart failure include cardiac neoplasms, constrictive pericarditis, or acute right ventricular failure (RVF). The Level III trainee should be aware of these less common conditions and understand their pathophysiology and management. The Level III trainee may not be expert in managing these conditions, but should be able to stabilize patients with them and seek guidance from the literature and from experts.

3.6. Research and Scholarly Activity

All trainees are expected to carry out research and/or engage in scholarly activities during Level III training in AHFTC. Scholarly activity related to heart failure, pulmonary hypertension, MCS, or transplant cardiology may include original clinical, basic science, translational, or interdisciplinary research; quality improvement activities; presentation at institutional, local, and national meetings; and publication of original articles, reviews, chapters, or case reports. Trainees should be encouraged to develop and maintain habits of self-learning and continuous professional improvement by reading heart failure and heart transplantation journals and attending journal clubs, conferences and appropriate scholarly meetings. A trainee's progress in research should be monitored by mentors through general oversight, direct observation, and critical review of presentations and manuscripts.

4. Training Requirements

4.1. Development and Evaluation of Core Competencies

Training requirements in AHFTC address the 6 general competencies promulgated by the ACGME and endorsed by the ABIM. These competency domains are Medical Knowledge, Patient Care and Procedural Skills, Practice-Based Learning and Improvement, Systems-Based Practice, Interpersonal and Communication Skills, and Professionalism. The ACC has used this structure to define and depict the components of the clinical competencies for cardiology. The curricular milestones for each competency

and domain also provide a developmental roadmap for fellows as they progress through various levels of training and serve as an underpinning for the milestones reported to ACGME. The ACC has adopted this format for its competency and training statements, career milestones, lifelong learning, and educational programs.

Table 1 depicts the 6 competency domains and their associated curricular milestones for training in AHFTC, as well as examples of evaluation tools suitable for assessing competence in each domain. The focus of this document is on delineation of the core competencies expected of *all* trainees in AHFTC upon successful completion of a standard one-year ACGME accredited AHFTC fellowship. These competencies are marked under the column "All". Certain areas of advanced knowledge or procedural skills are not typically encountered enough during a standard 12-month period of training to develop and demonstrate competence and therefore require additional dedicated exposure. These selected Level III competency components are designated in the "Add" column of the table, usually require additional training, and represent a skill level beyond that necessary for AHFTC certification. One year of formal training beyond the standard 3-year general cardiovascular fellowship, for example, is unlikely to confer expert competency in the management of the most complex patients undergoing heart transplantation or ventricular assist device implantation or those requiring other more specialized knowledge or procedural skills. These additional competencies may be obtained during or after the standard AHFTC fellowship, depending on the trainee's career focus and the opportunities available at the training program. The milestone interval indicates the stage by which the typical trainee will have achieved a particular competency. Although the competency components included in the "All" column should be achieved by all trainees and are appropriate areas for assessment, not every component need be individually assessed in every trainee. Rather, as with all educational activities, assessment is a sampling process that should be tailored to the needs of the individual trainee and program.

Table 1. Competency Components and Curricular Milestones for Level III Training in Advanced Heart Failure and Transplant Cardiology

Medical Knowledge	Milestones (Months)	
	All (12)	Add
Heart Failure		
1. Know the principles of excitation-contraction coupling and the contractile apparatus of the cardiomyocyte.	X	
2. Know the pathophysiology of heart failure, including such concepts as ventricular remodeling, neurohormonal activation, fetal gene expression, wall stress, signaling pathways (calcium, beta-adrenergic signaling, and nitric oxide), myocardial energetics, electrical and mechanical dyssynchrony, and the role of the extracellular matrix.	X	
3. Know common genetic underpinnings of both dilated and hypertrophic cardiomyopathy, their clinical phenotypes, and the role for genetic testing for patients and their families.	X	

4. Know important hemodynamic principles related to heart failure, including normal cardiac physiology, contractility, preload, afterload, and interpretation of pressure-volume loops and ventricular performance (Frank-Starling) curves.	X	
5. Know the epidemiology and risk determinants of left ventricular dysfunction, ventricular hypertrophy and heart failure (both with reduced and preserved ejection fraction), including incidence and prevalence overall and in special populations.	X	
6. Know classification methods of heart failure including American College of Cardiology/American Heart Association stages, New York Heart Association classes, and INTERMACS (Interagency Registry for Mechanically Assisted Circulatory Support) profiles.	X	
7. Know the risk factors, methods, and risk scores commonly used to stratify patients with heart failure, including their limitations, and how these methods are used to evaluate the need for advanced therapies.	X	
8. Know the epidemiology and pathophysiology of acute systolic or diastolic heart failure, including new-onset and acute-on-chronic heart failure.	X	
9. Know typical and atypical clinical presentations of patients with advanced heart failure (e.g., cachexia, worsening renal function, cognitive impairment, medication intolerance, ventricular tachycardia) and their management.	X	
10. Know the risks of arterial and venous thromboembolic complications in patients with heart failure.	X	
11. Know the pathophysiology, clinical presentation, and differential diagnosis of heart failure with preserved ejection fraction and its management.	X	
12. Know the pathophysiology, clinical presentation, and methods of risk stratification of patients with hypertrophic cardiomyopathy and its management.	X	
13. Know the distinguishing features of and appropriate diagnostic studies for specific etiologies of heart failure, including coronary artery disease, valvular heart disease, hypertension, myocarditis, infiltrative processes, toxins (e.g., illicit drugs), chemotherapy, pregnancy, congenital heart disease, radiation, pericardial processes, endocrinopathies, high-output states, stress cardiomyopathy, and inherited syndromes.	X	
14. Know the indications for percutaneous and surgical intervention for valvular heart disease in patients with heart failure.	X	
15. Know the evidence base, including randomized clinical trial data, supporting contemporary guideline-directed heart failure therapy.	X	
16. Know the pharmacology of common inotropes and vasopressors used in the management of low-output heart failure and shock.	X	
17. Know key principles regarding transitions of care between the outpatient and inpatient setting, and vice-versa, including indications for hospitalization and readiness for discharge for patients with heart failure.	X	
18. Know the role of assays for natriuretic peptide and other biomarkers in the management of patients with heart failure.	X	
19. Know the utility of noninvasive imaging (e.g., echocardiography, nuclear cardiology, cardiac magnetic resonance imaging, and positron emission tomography) in assessment of patients with cardiomyopathy (including those related to valvular heart disease) and heart failure.	X	
20. Know the strengths and limitations of common quality-of life-tools (e.g., Minnesota Living with Heart Failure and Kansas City Cardiomyopathy Questionnaire) used in patients with heart failure.	X	
21. Know which lifestyle choices and comorbidities (e.g., obstructive sleep apnea, depression, anemia, diabetes, hypertension, renal failure) contribute to the development of or clinical instability of patients with heart failure, as well as potential management options for such comorbid conditions.	X	
22. Know the roles of submaximal (including six-minute walk) and maximal exercise testing, and cardiopulmonary stress testing in patients with heart failure.	X	
23. Know the roles of implantable cardiac electronic device therapy in patients with heart failure, including cardioverter-defibrillators, pacemakers, and resynchronization devices.	X	
24. Know the roles of coronary imaging, ischemia testing, viability testing, and revascularization in patients with heart failure.	X	

25. Know the role of invasive hemodynamic assessment in patients with decompensated heart failure.	X	
26. Know the epidemiology and pathophysiology of the cardiorenal syndrome and its management.	X	
27. Know the pathophysiology of cardiac dysfunction associated with cirrhosis and the hemodynamic consequences of portal hypertension.	X	
28. Know the role of implantable technology to allow monitoring of patients with heart failure, including from afar (i.e., remote monitoring).	X	
29. Know the definition of frailty, tools available for assessment of frailty, and how frailty influences diagnosis, prognosis, and candidacy for advanced therapies in patients with heart failure.	X	
30. Know the roles of palliative and hospice care in patients with heart failure and the steps needed to implement them.	X	
31. Know the role of endomyocardial biopsy in the evaluation of myocarditis and infiltrative cardiomyopathies.	X	
32. Know the various chemotherapy agents associated with heart failure and the management of cardiac complications of chemotherapy.	X	
33. Know the potential contribution of arrhythmias to development of heart failure and/or decompensation and appropriate pharmacologic and ablation options for therapy.	X	
34. Know the roles of exercise training and cardiac rehabilitation in patients with heart failure with or without pulmonary hypertension, cardiac transplantation, or mechanical circulatory support.	X	
Pulmonary Hypertension		
35. Know the World Heart Organization classification and etiologies of pulmonary hypertension.	X	
36. Know the epidemiology, risk factors, prognostic factors, and natural history of pulmonary hypertension.	X	
37. Know the functional classes and appropriate treatment of patients with each type of pulmonary hypertension.	X	
38. Know the role of invasive hemodynamic assessment, including when to perform vasoreactivity testing to assess and manage patients with pulmonary hypertension, including pre- and post-capillary components.	X	
39. Know the classes of medications available to treat pulmonary hypertension and their use alone and in combination, including management of side effects.	X	
40. Know the roles of exercise and cardiopulmonary testing to assess and manage patients with pulmonary hypertension.	X	
41. Know the indications for referral to a specialized pulmonary hypertension center.	X	
42. Know the roles of balloon atrial septostomy, thromboendarterectomy, and lung transplantation in patients with pulmonary arterial hypertension.	X	
Mechanical Circulatory Support		
43. Know indications for and contraindications to both temporary and durable mechanical circulatory support for bridging and destination therapy.	X	
44. Know the expected survival following use of durable mechanical circulatory support.	X	
45. Know clinical determinants favoring mechanical circulatory support versus transplantation as durable strategies.	X	
46. Know optimal anticoagulation strategies for patients with ventricular assist devices.	X	
47. Know the management principles for patients with cardiogenic shock, including selection of temporary mechanical circulatory support.	X	
48. Know the management principles and potential complications of extracorporeal membrane oxygenation.	X	

49. Know the anatomic, surgical, and comorbid conditions that may impact mechanical circulatory support strategies in adult patients with congenital heart disease.	X	
50. Know intraoperative and early postoperative complications of durable mechanical circulatory support.	X	
51. Know the risk factors for and presentations and management of common complications of durable ventricular assist devices, including right heart failure, stroke, driveline infections, device thrombosis, hemolysis, gastrointestinal bleeding, and aortic insufficiency.	X	
52. Know risk scores that predict right heart failure in patients with left ventricular assist devices.	X	
Cardiac Transplantation		
53. Know the indications for and contraindications to heart transplantation.	X	
54. Know when patients listed for heart transplant need mechanical circulatory support, and the potential benefits and complications of this type of therapy.	X	
55. Know current United Network for Organ Sharing allocation listing policies for heart transplantation.	X	
56. Know the expected short- and long-term survival rates following heart transplantation.	X	
57. Know the role of multi-organ (e.g., heart-lung, heart-kidney, heart-liver) transplantation.	X	
58. Know the principles of immunology that pertain to heart transplantation, including sensitization and histocompatibility.	X	
59. Know and understand the efficacy, risks, and limitations of currently available methods for desensitization of patients awaiting heart transplantation.	X	
60. Know the preoperative considerations applicable to potential heart transplant recipients.	X	
61. Know the anatomic, surgical, and comorbid conditions that may impact transplant surgery planning and outcomes in adult patients with congenital heart disease, necessitating evaluation at a transplant center with expertise in these conditions.		X
62. Know the intraoperative and early postoperative complications of heart transplantation and their management.	X	
63. Know the process by which the heart procurement team interacts with teams procuring other organs from donors.	X	
64. Know the factors used to assess the suitability of a potential donor heart.	X	
65. Know the mechanisms of action, side effects, and potential drug-drug interactions of immunosuppressant drugs.	X	
66. Know how cardiac denervation impacts cardiac physiology, including response to exercise and pharmacological agents, and clinical manifestations of myocardial ischemia.	X	
67. Know the risk factors for, clinical presentations of, and treatment for hyperacute, acute cellular, and antibody-mediated rejection.	X	
68. Know the risk factors, clinical presentation, International Society for Heart & Lung Transplantation grading system, and strengths and limitations of diagnostic tools for cardiac allograft vasculopathy.	X	
69. Know when to consider cardiac re-transplantation.	X	
70. Know common post-transplant complications and how to monitor them in the outpatient setting, including hypertension, diabetes, malignancy, renal dysfunction, infection, obesity, and endocrinologic and neurological sequelae.	X	
71. Know the strengths and limitations of strategies used to detect and monitor transplant rejection.	X	
72. Know the grades of acute cellular and antibody-mediated transplant rejection, based on interpretation of an endomyocardial biopsy.	X	

73. Know the clinical presentation for common opportunistic infections in cardiac transplant recipients, as well as the potential for donor transmission of infectious organisms.	X	
Evaluation Tools: chart-stimulated recall, direct observation, in-training exam	X	
Patient Care and Procedural Skills		
Heart Failure		
1. Skill to oversee genetic testing of patients with cardiomyopathy, including selection of patients and collaboration with genetic counselors.	X	
2. Skills to optimize therapeutic regimens based on guideline-directed pharmacological and device-based therapies in stable patients with heart failure with reduced ejection fraction.	X	
3. Skill to estimate the jugular venous pressure by clinical examination.	X	
4. Skills to optimize a diuretic regimen in both the inpatient and outpatient settings.	X	
5. Skill to decide whether and when to hospitalize patients with heart failure.	X	
6. Skill to optimize pharmacological therapies in patients with decompensated heart failure, including adjustments after stabilization and prior to discharge.	X	
7. Skills to assess left ventricular systolic and diastolic properties noninvasively in patients with heart failure.	X	
8. Skill to select individualized diagnostic testing for patients with a new diagnosis of heart failure.	X	
9. Skill to minimize the risk of hospital readmission following discharge for decompensated heart failure.	X	
10. Skills to recognize and stabilize patients with cardiogenic shock.	X	
11. Skills to recognize and stabilize non-cardiogenic shock in patients with cardiomyopathy or a history of heart failure.	X	
12. Skills to perform and interpret findings from right heart catheterization in patients with heart failure.	X	
13. Skills to assess risk of patients with heart failure undergoing cardiac or noncardiac surgery, and to manage their hemodynamic status perioperatively.	X	
14. Skills to perform and interpret cardiopulmonary stress testing.	X	
15. Skills to initiate palliative and supportive care and to address symptoms and goals of care for patients with advanced heart failure across the care continuum.	X	
16. Skills to manage supraventricular and ventricular arrhythmias in patients with stable or decompensated heart failure.	X	
17. Skill to collaborate with cardiac electrophysiologists to stabilize patients with ventricular tachycardia storm complicating cardiomyopathy, heart failure or mechanical circulatory support.	X	
18. Skill to collaborate with cardiac surgeons, interventional cardiologists, or members of a structural heart care team to determine whether percutaneous or surgical valve intervention is necessary for patients with heart failure.	X	
19. Skills to work effectively with experts in adult congenital heart disease to assess and manage patients with these conditions, including determining when to employ mechanical support or cardiac transplantation.	X	
20. Skill to determine the indications for coronary revascularization in patients with ischemic cardiomyopathy.	X	

21. Skills to interrogate implantable cardioverter-defibrillators, cardiac resynchronization pacemakers, and cardiac resynchronization-defibrillator devices in patients with cardiomyopathy and/or heart failure to determine the burden of arrhythmias, diagnostic information, and basic device functionality.	X	
22. Skill to determine when patients are inotrope-dependent and to manage them in the outpatient setting.	X	
23. Skill to work effectively with obstetricians in the care of pregnant patients with a cardiomyopathy and/or heart failure.	X	
24. Skill to provide self-help tools to patients with heart failure to minimize the risk of decompensation.	X	
25. Skills to educate heart failure patients about warning signs that signify or predict clinical instability, and to help them develop action plans in the event warning signs appear.	X	
Pulmonary Hypertension		
26. Skill to evaluate patients with pulmonary hypertension to determine etiology.	X	
27. Skill to recommend the initial pharmacological regimen for patients with pulmonary arterial hypertension.	X	
28. Skills to assess functional capacity and risk stratify patients with pulmonary arterial hypertension.	X	
29. Skills to perform serial noninvasive assessments of right ventricular function and pulmonary arterial pressure and integrate these data in the management of patients with pulmonary hypertension.	X	
30. Skills to detect clinical deterioration in patients with pulmonary hypertension and adjust treatment accordingly, including determining when hospitalization is necessary.	X	
31. Skill to stabilize patients with acute right ventricular failure in the setting of pulmonary hypertension.	X	
Mechanical Circulatory Support		
32. Skill to identify appropriate options for temporary hemodynamic support for patients in cardiogenic shock.	X	
33. Skill to identify appropriate candidates for durable ventricular assist devices.	X	
34. Skills to interrogate, interpret, and manipulate pump parameters in patients with temporary and durable hemodynamic assist devices.	X	
35. Skill to recognize the indications for total artificial heart or right ventricular assist device rather than left ventricular assist device alone.		X
36. Skill to optimally set the speed of durable ventricular assist devices.	X	
37. Skills to select and interpret noninvasive and invasive data to evaluate patients with temporary and durable ventricular assist devices (e.g., ramp study, aortic valve opening or right ventricular assessment).		X
38. Skills to identify and manage right heart failure in patients with left ventricular assist devices.	X	
39. Skill to manage long-term durable mechanical circulatory support in the outpatient setting.	X	
40. Skills to recognize and manage complications of durable mechanical circulatory support, including stroke, device thrombosis, right heart failure, hypertension, or arrhythmias.	X	
41. Skills to recognize left ventricular recovery and assess patients with left ventricular assist devices for potential explantation.		X
42. Skill to determine whether and when to hospitalize patients with durable ventricular assist devices.	X	
43. Skill to select management options (including hospitalization and diagnostic investigation) for patients with durable ventricular assist devices and gastrointestinal bleeding.	X	

44. Skills to collaborate with anesthesiologists and procedural specialists to optimize management during invasive procedures or noncardiac surgery in patients with continuous flow, durable ventricular assist devices.	X	
Cardiac Transplantation		
45. Skill to determine whether and when patients warrant cardiac transplantation.	X	
46. Skill to recognize comorbidities that preclude cardiac transplantation.	X	
47. Skill to recognize irreversible pulmonary hypertension that precludes isolated heart transplantation.	X	
48. Skill to assess the suitability of a given heart for transplantation in a potential recipient.	X	
49. Skills to adjust immunosuppressant therapy to minimize the risk of rejection, while balancing competing risks of infection, malignancy, renal failure, and other toxicities.		X
50. Skill to collaborate with colleagues in the histocompatibility laboratory to assess a heart transplant recipient's reactive antibody panel, pre-formed and post-transplant anti-human leukocyte antigen antibodies, and immunologic compatibility with a donor heart.	X	
51. Skill to manage heart transplant recipients in the immediate post-transplant period, including those with complications, in conjunction with a multidisciplinary team.	X	
52. Skill to determine whether and when illness in heart transplant recipients requires hospitalization.	X	
53. Skills to interpret with a pathologist the findings of endomyocardial biopsies to determine the need for treatment of acute cellular or antibody-mediated rejection, and oversee treatment.	X	
54. Skills to collaborate with other members of a multidisciplinary team in managing common comorbidities and complications following heart transplantation, including hypertension, dyslipidemia, renal insufficiency, infection, and cancer.	X	
55. Skills to collaborate with invasive and interventional cardiologists in the prevention, recognition, and treatment of transplant vasculopathy.	X	
56. Skills to interpret noninvasive tests, including echocardiograms, gene expression profiling (e.g., Allomap testing), and other biomarkers to evaluate for rejection in heart transplant recipients.	X	
57. Skill to perform endomyocardial biopsy to assess for transplant rejection.	X	
58. Skill to prescribe therapies to prevent opportunistic infections, including Cytomegalovirus, Nocardia, and Pneumocystis Jirovecii pneumonia in heart transplant recipients.	X	
59. Skill to oversee the use of immunizations in patients before and after cardiac transplantation.	X	
Evaluation Tools: chart-stimulated review, direct observation, multisource evaluation		
Systems-Based Practice		
1. Utilize appropriate care settings and teams for patients with various profiles and stages of heart failure before or after mechanical circulatory support or transplantation.	X	
2. Incorporate risk/benefit analysis and cost considerations in diagnostic and treatment decisions, including the adoption of new technologies.	X	
3. Utilize an interdisciplinary, coordinated team approach for patient management, including care transitions, palliative care, and employment-related issues.	X	
4. Effectively utilize an interdisciplinary transitional-care approach to monitor the progress of ambulatory patients with heart failure to maintain stability and avoid preventable hospitalization.	X	
5. Collaboratively work with all members of the advanced heart failure and transplant cardiology team, including cardiac surgeons, palliative care specialists, other medical consultants, nurses, nurse practitioners, physician assistants, social workers, dietitians, physical and occupational therapists, and pharmacists.	X	
6. Identify the financial, cultural, social, and emotional barriers to successful outcomes after mechanical circulatory support or transplantation.	X	

7. Effectively utilize an interdisciplinary approach to care for patients with or at risk of advanced heart failure, pulmonary hypertension, and mechanical circulatory support or cardiac transplantation.	X	
Evaluation Tools: chart-stimulated recall, direct observation, multisource evaluation		
Practice-Based Learning and Improvement		
1. Identify knowledge and performance gaps and engage in opportunities to achieve focused education and performance improvement.	X	
2. Utilize decision support tools to access guidelines and pharmacologic information at the point of care.	X	
3. Incorporate feedback from faculty and staff to improve performance.	X	
4. Develop habits of regular and critical reading of the heart failure/transplant literature to maintain current knowledge of the field and promote lifelong learning.	X	
Evaluation Tools: conference presentation, direct observation, global evaluation, reflection and self-assessment		
Professionalism		
1. Show compassion for and effective management of end-of-life issues, including discussions of death and dying, across the spectrum of patients with heart failure, pulmonary hypertension, mechanical circulatory support, or heart transplantation.	X	
2. Clearly and objectively discuss available therapies for advanced heart failure, including palliative care, mechanical circulatory support, or transplantation.	X	
3. Interact respectfully with patients, families, and all members of the healthcare team, including ancillary and support staff.	X	
4. Demonstrate high ethical standards, including the recognition and management of overt and more subtle potential conflicts of interest, when making diagnostic or therapeutic decisions.	X	
Evaluation Tools: conference presentation, direct observation, multisource evaluation, reflection and self-assessment	X	
Interpersonal and Communication Skills		
1. Communicate with and educate patients and families across a broad range of cultural, ethnic, and socioeconomic backgrounds.	X	
2. Engage in shared decision making, including the potential role of palliative care and discussing the risk of death, with patients and their families considering mechanical circulatory support and/or transplant.	X	
3. Effectively lead the interdisciplinary heart failure team to promote comprehensive and balanced decision making with respect to the selection of mechanical circulatory support versus heart transplantation.	X	
4. Skill to discuss the potential for donor transmission of infectious agents to the recipient, and ability to use a shared decision-making approach with recipients when assessing a donor at risk.	X	
5. Skill to provide emotional support to patients and their families before and after mechanical circulatory support or cardiac transplantation.	X	
Evaluation Tools: direct observation, multisource evaluation		

Add = Additional competencies that extend beyond the core expectations and that may be achieved by some AHFTC specialists based on career focus, either during or following formal AHFTC fellowship training (see text for details).

4.2. Number of Procedures

An essential component of training an AHFTC practitioner is robust understanding of the indications for, contraindications to, and complications of procedures commonly performed in patients with advanced heart failure, including ventricular assist devices and cardiac transplantation (Table 2). Each trainee

should maintain a record that documents the indications, outcomes, and diagnoses associated with procedures they performed or attempted, along with the name of the supervising faculty member.

It is axiomatic that direct supervision of invasive procedures performed by trainees must occur until the trainee demonstrates sufficient proficiency and judgment, attainment of which must be documented by the Program Director. Faculty members must teach and supervise trainees in the performance and interpretation of procedures. Trainees must participate in pre-procedural planning and post-procedural management.

In addition to the skills to safely perform procedures, the trainee must possess the skills to determine the appropriate procedure, obtain and interpret procedural data, and utilize the data to optimize patient care. The suggested minimum procedural volumes during AHFTC training are shown in Table 2.

Table 2. Recommendations for Minimum Procedural Volume or Technical Experience to Achieve and Demonstrate Competence in Advanced Heart Failure and Transplant Cardiology

Procedure/Technical Skill	**Numbers***
Observe and interpret CPX	Observe 5 Interpret 20
Perform and interpret right heart catheterization	50, of which at least 30 should be pre-transplantation
Perform and interpret pulmonary vasodilator challenge in pulmonary hypertension†	5
Interrogate ICDs and CRT devices	20/20 (*or* document comparable training during general cardiology fellowship *and* review 3 ICD and 3 CRT interrogations with an EP attending who attests to the competency expected of AHFTC physicians)
Observe implantation of VADs	3
Perform and interpret VAD interrogation	10
Oversee the medical care, including anticoagulation and VAD speed setting, of LVAD recipients	15 (of which 5 must be during index hospitalization of LVAD implantation)
Perform and interpret LVAD ramp procedures†	10
Observe procurement of donor organs	3
Observe cardiac transplant surgery	3
Oversee the medical care, including immunosuppressive regimen, of a cardiac transplant recipient	30 (of which 5 must be during index transplant hospitalization)
Perform endomyocardial biopsies, femoral access	5
Perform endomyocardial biopsies, internal jugular access	45
Review endomyocardial specimens, with a range of pathology, in collaboration with a pathologist	20
Interpret the severity of CAV from a coronary angiogram utilizing the ISHLT Cardiac Allograft Vasculopathy Grading scale	10
Participate in end-of-life and/or palliative care discussions	10

*Recommendations for number of procedures required are based on consensus recommendations and indicate numbers that should be performed and/or interpreted successfully to achieve competence. These numbers are intended as general guidance, based on the educational needs and progress of typical AHFTC trainees. Competency

to perform each procedure must be based on evaluation by the supervising physician and may exceed or be below the threshold number shown in Table 2.

†acquired during additional months beyond a dedicated 12-month advanced heart failure/transplant fellowship.

AHFTC indicates advanced heart failure and transplant cardiology; CAV, cardiac allograft vasculopathy; CPX, cardiopulmonary exercise testing; CRT, cardiac resynchronization therapy; EP, electrophysiology; ICD, implantable cardioverter-defibrillator; ISHLT, International Society for Heart & Lung Transplantation; LVAD, left ventricular assist device; and VAD, ventricular assist device.

4.3. Heart Failure

The AHFTC trainee should know the pathophysiology of heart failure at the molecular, cellular, and organ levels, including the roles of neurohormonal activation and ventricular remodeling in disease progression. They also should know the diagnostic and management strategies for patients with heart failure due to ischemic and nonischemic forms of heart disease, including infiltrative cardiomyopathies, inherited cardiomyopathies, and cardiomyopathies related to endocrinopathy, pregnancy, chemotherapy and other toxins such as illicit drugs, as well as those with adult congenital heart disease (3). Trainees should become proficient in the management of both acute and chronic heart failure using available pharmacotherapies, and acquire a deep understanding of the evidence base developed from randomized trials that underlie guideline-directed therapies (7). They should be familiar with the epidemiology, common genetic abnormalities, and risk factors for heart failure and know how to assess and manage commonly encountered comorbidities in patients with heart failure. The AHFTC trainee should develop the skills to identify advanced heart failure, direct an evaluation, and determine the appropriateness of patients for cardiac transplantation, MCS, or palliative care (3).

4.3.1. Inpatient

The AHFTC trainee should learn the pathophysiology and epidemiology of various acute heart failure syndromes, including coronary ischemia, accelerated hypertension, decompensated heart failure, cardiogenic shock, and right heart failure in patients with and without heart transplantation or MCS. As the prevalence of heart failure with preserved ejection fraction is approximately 50%, trainees should know the pathophysiology (e.g., impaired diastolic relaxation, myocardial stiffening, ventricular-arterial coupling), clinical presentation, differential diagnosis and management of acute decompensations of patients with this type of heart failure. Trainees should also become skilled in selection of an optimal diuretic regimen, know the role of vasodilator and inotropic therapy, employ measures to prevent thromboembolic complications, know criteria for discharge of hospitalized patients with heart failure, and facilitate safe transition to the outpatient setting.

4.3.1.1. Initial Assessment

The AHFTC trainee should rapidly identify patients with heart failure in danger of hemodynamic collapse or death and know how to stabilize them. A key element of the initial assessment is to identify factors that precipitate hospitalization for heart failure. In addition, proficiency in obtaining a history and performing a physical examination is essential to assessing a patient's hemodynamic profile (8), and this must be integrated with hemodynamic and physiologic data in patients presenting with decompensated heart failure.

4.3.1.2. Hemodynamic Interpretation

Although invasive hemodynamic monitoring is not routinely indicated in the management of patients with acute heart failure, trainees should become familiar with indications for pulmonary artery catheterization as supported by the 2013 ACC/AHA Guideline for the Management of Heart Failure (7). Trainees should acquire the skills to troubleshoot pulmonary artery catheters in the catheterization laboratory and intensive care unit, and to interpret hemodynamic parameters measured by this technology, including the right atrial pressure, pulmonary artery pressure, pulmonary capillary wedge pressure, cardiac output and index, and derived variables including pulmonary and systemic vascular resistances. Trainees should learn to utilize echocardiographically-derived estimates of filling pressures and cardiac output to guide therapy.

4.3.1.3. Cardiogenic Shock

The AHFTC trainee should recognize and stabilize patients with cardiogenic shock, and distinguish this from other causes of shock. Trainees should learn the indications for, contraindications to, and clinical pharmacology of intravenous vasopressor and inotropic agents in patients with advanced heart failure, and recognize patients chronically dependent upon these agents. Trainees should promptly identify patients with refractory cardiogenic shock and assess candidates for temporary MCS devices in the context of long-term treatment goals (implantable ventricular assist devices, explantation after myocardial recovery, heart transplantation, bridging to decision, or palliative care). Familiarity with available temporary support device is crucial, and trainees should troubleshoot temporary MCS devices in conjunction with a multidisciplinary team. Trainees should know the role of palliative and hospice care in patients with advanced heart failure. Ongoing care should address symptom control, psychosocial distress, health-related quality of life, end-of-life care, caregiver support, and access to evidence-based disease-modifying interventions.

4.3.1.4. Decompensated Heart Failure

Trainees should become proficient in supervising patients hospitalized with decompensation of chronic heart failure through initial stabilization and optimization of therapy. Management issues include optimizing volume status through selection of an appropriate diuretic regimen, recognition of risk factors for the cardiorenal syndrome, implementation of inotropic therapy when indicated, considerations in use of renal replacement therapy, conversion from intravenous to oral diuretic medications, and initiation or modification of guideline-directed medical therapy during the hospitalization and at discharge. Trainees should become facile with other aspects of management that may arise during hospitalization, including treatment of arrhythmias, ICDs or CRT device interrogation to determine arrhythmia burden and functionality of the device, and assessment of the role of coronary revascularization. Trainees should be able to identify patients whose clinical course is on a downward trajectory, including those with who should receive MCS, cardiac transplantation, or end-of-life care. Trainees should become proficient in facilitating safe transitions of outpatient care that minimize the likelihood of readmission for heart failure.

4.3.2. Outpatient

Trainees should learn the various methods of classifying heart failure, including the ACC/AHA stages, New York Heart Association (NYHA) classes, and INTERMACS profiles, as well as the epidemiology and risk determinants applicable to patients with heart failure with reduced and preserved ejection fraction. The AHFTC trainee should learn how to direct the outpatient evaluation of patients with recently identified heart failure to identify specific etiologies and understand the role of genetic testing. Various tools are available to assess patients with heart failure, including the clinical history and physical examination, multimarker risk scores, quality of life assessments, natriuretic peptide testing, stress testing including cardiopulmonary stress tests, and noninvasive imaging techniques. Trainees should become comfortable with each of these modalities and know their strengths and limitations. Trainees should learn how to up-titrate guideline-directed medical therapy to achieve appropriate targets. Clinical deterioration in an outpatient and indications for hospitalization should be recognized. Trainees should learn how to incorporate advanced care planning and end-of-life discussions in the outpatient setting.

4.4. Pulmonary Hypertension

Pulmonary hypertension (PH) treatment involves important elements of hemodynamic management of pulmonary artery pressures and right heart failure. The AHFTC trainee should be able to manage, or co-manage with a PH care team, patients with pulmonary hypertension from Class I to advanced Class IV stages.

4.4.1. Inpatient

AHFTC trainees should learn how to detect clinical deterioration in hospitalized patients with pulmonary hypertension, adjust treatment accordingly, and stabilize those with acute RVF using parenteral therapies in conjunction with a multidisciplinary team. Further, they should learn the appropriate use of invasive hemodynamic monitoring and know when to refer patients to a pulmonary hypertension specialist.

4.4.2. Outpatient

In coordination with a PH care team, the AHFTC trainee should learn to classify patients according to the World Heart Organization criteria regarding etiology, risk-stratify patients with respect to treatment requirements, understand the role of exercise testing, and initiate guideline-based therapy for patients with PH, cognizant of the pharmacologic options for PH, including combination therapies and their side effects. The trainee should recognize clinical worsening, adjust treatment as necessary, and appropriately refer patients for more advanced PH care, including balloon atrial septostomy or lung transplantation.

4.5. Mechanical Circulatory Support

A much broader group of individuals will seek competency in advanced heart failure cardiology than will directly manage patients with durable left ventricular assist devices (LVADs) on a daily basis. Nevertheless, MCS is an important therapeutic option for patients with advanced heart failure, including those with cardiogenic shock, and all AFHTC trainees should acquire competency in the use of these technologies. Trainees should understand the results of relevant clinical trials and registry data, maintain currency on contemporary guidelines for management of patients with mechanical support (9-11), and keep abreast of emerging MCS technologies. It is essential that trainees learn to identify appropriate candidates for temporary hemodynamic support and durable ventricular assist devices. Trainees should appreciate the value of a multidisciplinary team approach to MCS by fostering collaborative relationships with cardiac surgeons, intensivists, advanced practice providers, social workers, infectious disease, palliative care specialists, ventricular assist device coordinators, and other team members.

4.5.1. Inpatient

The trainee must acquire the medical knowledge and clinical skills to identify candidates for temporary and/or durable MCS, including those needing biventricular support. The trainee should know the indications for and contraindications to temporary hemodynamic support, be able to troubleshoot devices used in their institution, and develop skills to manage patients in the early post-implant period in conjunction with the multidisciplinary team.

Patients on durable left ventricular assist device (LVAD) support may present with a variety of complications. These complications include RVF, gastrointestinal bleeding, driveline infections, arrhythmias, pump thrombosis, and aortic insufficiency. The trainee should know and recognize risk factors for these complications, and understand how to manage them. Because early RVF portends a poor prognosis following LVAD implantation, the trainee should recognize preoperative risk factors for RVF, understand perioperative management strategies aimed at minimizing risk of RVF, and appreciate circumstances in which biventricular support or transplant may be indicated. The trainee should master the skills necessary to manage RVF that develops after LVAD deployment. The skill set must also include 1) understanding of durable LVAD device parameters and how to interpret or manipulate changes in these parameters in clinical context; 2) management of anticoagulation; 3) recognition and management of pump thrombosis; 4) development of professional rapport with surgical, gastrointestinal, and infectious disease colleagues, all of whom play an integral role in helping to manage LVAD complications; and 5) management of patients facing imminent death, including relief of symptoms. Interested trainees should develop the abilities to perform and interpret ramp echocardiograms to assess likelihood of LVAD thrombosis, though these skills may require additional training beyond the typical 12-month AHFTC fellowship.

Finally, because failure to communicate openly and fully with patients and caregivers may contribute to unrealistic expectations or unmet needs for care, the trainee should master the ability to communicate effectively regarding prognosis, level of understanding, and end-of-life preferences, and foster a close working relationship with palliative care specialists.

4.5.2. Outpatient

Patients supported with durable ventricular assist devices require frequent monitoring in the outpatient setting. The trainee should develop the skills to manage patients in this setting, including 1) optimal titration of pharmacotherapies for heart failure, hypertension, and anticoagulation; 2) diagnostic interrogation of device-specific pump parameters to inform therapy, including optimization of LVAD speed; 3) identification of complications that require hospital admission; and 4) recognition of patients with LV recovery who may benefit from device explantation.

4.6. Cardiac Transplantation

The 12 additional months of an AHFTC fellowship required for Level III training may not provide the experience in cardiac transplantation required for qualification as a heart transplant physician under UNOS criteria (12). A broader group of individuals will seek competency in advanced heart failure cardiology than will directly manage patients undergoing cardiac transplantation. Nonetheless, many

programs offer an experience within the Level III curriculum to establish competency in the care of patients undergoing transplantation that meets the UNOS criteria.

Most importantly, through interaction with a wide variety of patients at different stages in the transplant process, with different levels of acuity, socioeconomic and cultural backgrounds, healthcare knowledge and preferences, the trainee will acquire necessary competence and expertise in pre- and post-transplant management as outlined in the competency milestones (Table 1).

4.6.1. Inpatient

4.6.1.1. Pretransplant Management

Trainees must learn the approach to recipient selection, focusing on identification of candidates ill enough to merit transplantation yet free of medical or psychosocial contraindications (13), and also know how to evaluate the quality of a potential donor heart. Trainees should learn UNOS allocation listing policies, including when to apply for exception for candidates who do not meet stated criteria for a given status yet have a comparable severity of illness. Trainees should become familiar with the management of the sensitized patient, including interpretation of panel reactive antibodies and understand desensitization regimens, including but not limited to plasmapheresis, intravenous immune globulin, rituximab, and bortezomib. Trainees should be exposed to the unique issues involved in considering transplantation for patients with adult congenital heart disease.

4.6.1.2. Acute Postoperative Management

The postoperative management of heart transplant recipients starts with donor evaluation and organ procurement. Trainees should become familiar with the logistics of these steps and gain experience interpreting virtual, prospective and retrospective cross-matches, determining the need for induction therapy, and managing initial post-transplant immunosuppression and infection prophylaxis.

4.6.1.3. Postoperative Complications

Trainees should become familiar with early postoperative hemodynamics and be able to direct subsequent testing to distinguish such complications as primary graft dysfunction, delayed hyperacute rejection, right heart failure related to pulmonary hypertension, and cardiac tamponade. They should become competent as part of a multidisciplinary team in caring for patients requiring temporary mechanical support such as extracorporeal membrane oxygenation. Trainees should develop the skills to manage potential donor-derived infections and malignancies, including informing patients and families of these events, and

appropriately consult specialists for further evaluation and management. Trainees should be able to manage other common complications in the early postoperative setting, including early rejection, bradyarrhythmias and tachyarrhythmias, thromboembolism, delirium, and infections.

4.6.1.4. Inpatient Heart Transplant Management Following the Index Admission

Heart transplant patients may be re-admitted months or years after transplantation for cardiac or noncardiac problems, such as acute cellular or antibody-mediated rejection, graft failure, transplant vasculopathy, infections, or malignancy. Trainees will be exposed to heart transplant recipients with these complications and should acquire the skills to direct the care of such patients. Trainees should collaborate with cardiac pathologists interpreting biopsies, interventional cardiologists considering percutaneous intervention, and infectious disease specialists treating opportunistic infections (14). Given that the side effects and toxicities of immunosuppression affect many organ systems, the AHFTC trainee will consult with numerous other specialists as well. It is particularly important for trainees to learn the extra-cardiac toxicities of immunosuppression, such as the neurotoxicity and nephrotoxicity of calcineurin inhibitors, pulmonary toxicity of proliferation signal inhibitors, and gastrointestinal toxicity of mycophenolate mofetil, as patients will likely present symptoms of these conditions initially to the AHFTC specialist (15).

4.6.2. Outpatient

4.6.2.1. Immunosuppression

The major goal of outpatient management of a heart transplant recipient is to maximize benefit and minimize toxicity of immunosuppression. Level III trainees should become familiar with strategies to individualize immunosuppression based on the patient's risk of rejection and infection, as guided by a history of rejection or infection, medication tolerance, antibody sensitization, compliance, presence of transplant vasculopathy, malignancy, peripheral blood gene-expression profiling, and results of T-cell immune function assays. They should learn the role of standard triple-drug immunosuppression with a calcineurin inhibitor, an antimetabolite most commonly mycophenolate mofetil, and corticosteroids, and know when to consider proliferation signal inhibitors, sirolimus or everolimus. Trainees should become familiar with methodologies for rejection surveillance and adjunctive immunotherapies for patients with recurrent rejection.

4.6.2.2. Chronic Complications

Chronic immunosuppression places patients at risk of hypertension, obesity, drug-drug interactions, renal dysfunction, gout, diabetes, dyslipidemia, osteoporosis, infections, malignancy, and other disorders. Thus, trainees should learn appropriate screening and prevention strategies, including immunization, and develop the skills to manage complications in conjunction with other providers. Long-term care of heart transplant recipients includes screening for and management of transplant vasculopathy. Trainees should learn the appropriate triage to revascularization, retransplantation, or end-of-life management.

4.7. Shared Decision Making and Palliative Care

According to the ACCF/AHA Guideline for the Management of Heart Failure, "palliative and supportive care is effective for patients with symptomatic heart failure to improve quality of life" (7). Furthermore, given the acuity of illness to which patients with heart failure are prone, trainees require advanced communication skills to care for critically ill patients and those with complications following LVAD implantation or cardiac transplantation. Trainees should incorporate palliative care throughout the spectrum of illness and know when to consult palliative care specialists. Discussions focused on shared decision making provide patients, families, and providers opportunities to work together to make decisions about care and choose treatment options that are aligned with the patient's values, goals and preferences (16). For example, trainees should acquire experience re-evaluating and revising the medical regimen and modify device-based therapy as goals of care change toward the end of life.

5. Evaluation of Proficiency

Evaluation tools in AHFTC training include direct observation by instructors, case logbooks, conference and case presentations, multisource evaluations, trainee portfolio/curriculum vitae, in-training exam, and simulation. Self-assessment programs are available through the ACC and HFSA (Heart Failure Society of America). Program directors and trainees are encouraged to incorporate these resources in the course of training. Following completion of AHFTC training, trainees will be eligible to take the ABIM Board Certification Examination in AHFTC.

Judgment, case management, and bedside and procedural skills must be evaluated regularly in every trainee. Quality of care and follow-up, reliability, judgment or decisions or actions that result in complications, interaction with other physicians, patients, and laboratory support staff, initiative, and the ability to make appropriate decisions independently should be considered. Trainees should maintain records of participation and advancement in the form of a Health Insurance Portability and Accountability Act (HIPAA)-compliant electronic database or logbook that meets ACGME reporting standards and

summarizes pertinent clinical information (number of cases, diagnoses, disease severity, outcomes and disposition for each encounter).

Under the guidance of the program director, faculty should verify and document each trainee's experiences, assess performance, and confirm satisfactory achievement. The program director is responsible for confirming experience and competence and reviewing the overall progress of individual trainees with the Clinical Competency Committee to ensure achievement of selected training milestones and identify areas in which additional focused training may be required.

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KEY WORDS: ACC/AHA/HFSA/ISHLT/ACP Training Statement, advanced heart failure, clinical competence, fellowship training, mechanical circulatory support, pulmonary hypertension, transplant cardiology, training milestones, cardiomyopathy, heart transplantation, ventricular assist devices

APPENDIX 1. AUTHOR RELATIONSHIPS WITH INDUSTRY AND OTHER ENTITIES (RELEVANT)—ACC/AHA/HFSA/ISHLT/ACP ADVANCED TRAINING STATEMENT ON ADVANCED HEART FAILURE AND TRANSPLANT CARDIOLOGY

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ABIM indicates American Board of Internal Medicine; ACC, American College of Cardiology; ACP, American College of Physicians; AHA, American Heart Association; APFED, American Partnership for Eosinophilic Disorders; CDC, Centers for Disease Control and Prevention; HFSA, Heart Failure Society of America; ISHLT, The International Society for Heart & Lung Transplantation; NHLBI, National Heart, Lung, and Blood Institute; and NIH, National Institutes of Health.

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ABIM indicates American Board of Internal Medicine; ACC, American College of Cardiology; AHA, American Heart Association; AHFTC, advanced heart failure and transplant cardiology; COCATS, Core Cardiovascular Training Statement; HF&T, Heart Failure & Transplant; NHLBI, National Heart, Lung, and Blood Institute; NIH, National Institutes of Health; and VA, Veterans Affairs.

APPENDIX 3. ABBREVIATION LIST

ABIM = American Board of Internal Medicine

ACC = American College of Cardiology

ACGME = Accreditation Council for Graduate Medical Education

ACLS = advanced cardiovascular life support

ACP = American College of Physicians

AHA = American Heart Association

AHFTC = advanced heart failure and transplant cardiology

COCATS = Core Cardiovascular Training Statement

CRT = cardiac resynchronization therapy

HFSA = Heart Failure Society of America

HIPAA = Health Insurance Portability and Accountability Act

ICD = implantable cardioverter-defibrillator

INTERMACS = The Interagency Registry for Mechanically Assisted Circulatory Support

ISHLT = The International Society for Heart & Lung Transplantation

LVAD = left ventricular assist device

MCS = mechanical circulatory support

NYHA = New York Heart Association

PH = pulmonary hypertension

RVF = right ventricular failure

RWI = relationships with industry

UNOS = United Network for Organ Sharing