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TRAINING STATEMENT

COCATS 4 Task Force 5: Training in Echocardiography

Endorsed by the American Society of Echocardiography

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1. INTRODUCTION

1.1. Document Development Process

1.1.1. Writing Committee Organization

The writing committee was selected to represent the American College of Cardiology (ACC) and American Society of Echocardiography (ASE) and included a cardiovascular training program director, an echocardiography training program director, early-career echocardiography experts, highly experienced specialists practicing in both the academic and community-based practice settings, and physicians experienced in defining and applying training standards according to the 6 general competency domains promulgated by the Accreditation Council for Graduate Medical Education (ACGME) and American Board of Medical Specialties (ABMS) and endorsed by the American Board of Internal Medicine (ABIM). The ACC determined that relationships with industry or other entities were not relevant to the creation of this general cardiovascular training statement. Employment and affiliation details for authors and peer reviewers are provided in Appendixes 1 and 2, respectively, along with disclosure reporting categories. Comprehensive disclosure information for all authors, including relationships with industry and other entities, is available as an online supplement to this document.

1.1.2. Document Development and Approval

The writing committee developed the document, approved it for review by individuals selected by the ACC and ASE, and addressed the reviewers' comments. The document was revised and posted for public comment from December 20, 2014, to January 6, 2015. Authors addressed the additional comments from the public to complete the document. The final document was approved by the Task Force, COCATS Steering Committee, and ACC Competency Management Committee; ratified by the ACC Board of Trustees in March, 2015; and endorsed by the ASE. This document is considered current until the ACC Competency Management Committee revises or withdraws it.

1.2. Background and Scope

Echocardiography is the most widely used and readily available imaging technique for assessing cardiovascular anatomy and function. Clinical application of ultrasound encompasses M-mode, 2-dimensional (2D), 3-dimensional (3D), pulsed, tissue, and continuous-wave Doppler and color-flow imaging. Echocardiography noninvasively provides diagnostic and prognostic information concerning cardiovascular anatomy, function (i.e., ejection fraction), hemodynamic variables (i.e., gradient or pressure), and flow disturbances by means of pulsed, continuous-wave, and color-flow Doppler imaging. Moreover, these cardiovascular parameters can be assessed at rest, as well as during conditions of increased hemodynamic demand such as exercise.

The Task Force was charged with updating previously-published standards for training clinical adult cardiovascular fellows on the basis of changes in the field since 2008 and as part of a broader effort to establish consistent training criteria across all aspects of cardiology. The changes herein address the necessary balance between the development of increasingly specialized and sophisticated

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echocardiographic techniques and the need to provide a broad and complete training experience within a 3-year fellowship period. The Task Force also updated previously published standards to address the evolving framework of competency-based medical education described by the ACGME Outcomes Project and the 6 general competencies endorsed by the ACGME and ABMS. The background and overarching principles governing fellowship training are provided in the COCATS 4 Introduction, and readers should become familiar with this foundation before considering the details of training in a subdiscipline like echocardiography. The Steering Committee and Task Force recognize that implementation of these changes in training requirements will occur incrementally over time.

For most areas of adult cardiovascular medicine, 3 levels of training are delineated:

- **Level I training**, the basic training required for trainees to become competent consultants, is required by all fellows in cardiology and can be accomplished as part of a standard 3-year training program in cardiology. For echocardiography, Level I training is defined as an introductory or early level of competency in performing and interpreting transthoracic echocardiography (TTE) that is achieved during fellowship training but not sufficient to provide independent interpretation of results.
- **Level II training** refers to the additional training in 1 or more areas that enables some cardiovascular specialists to perform or interpret specific diagnostic tests and procedures or to render more specialized care for patients and conditions. This level of training is recognized for those areas in which an accepted instrument or benchmark, such as a qualifying examination, is available to measure specific knowledge, skills, or competence. Level II training in selected areas may be achieved by trainees during the standard 3-year cardiovascular fellowship, depending on their career goals and use of elective rotations. Level II training in echocardiography is required to provide independent interpretation of echocardiograms.
- **Level III training** usually requires additional experience beyond the standard 3-year cardiology fellowship to acquire specialized knowledge and competencies in performing, interpreting, and training others to perform specific procedures or render advanced, specialized care at a high level of skill and are defined by competency components and outcome metrics. The skills and experience achieved during Level III training prepare the trainee to perform and interpret complex studies in special populations, engage in research, direct an academic echocardiography laboratory, and train others in advanced aspects of echocardiography. These advanced competencies are usually not covered during the general cardiology fellowship, but require additional training during which they are integrated with training in other imaging modalities. For selected fellows wishing to attain advanced competencies in echocardiography, training beyond Level II can be achieved either during the standard 3-year fellowship (for those individuals seeking dedicated Level III training focused on echocardiography) or during an additional period of training beyond the standard 3-year fellowship for those desiring advanced echocardiography competency as part of multimodality imaging training. Fellows pursuing this advanced training during the 3-year fellowship will devote all available elective time to echocardiography, precluding acquisition of Level II competency in any other imaging modality. In both pathways, Level III training in echocardiography should take place in laboratories with Level III-trained faculty and with the necessary infrastructure to provide the advanced training experience. Level III training is described here in relatively broad terms to provide context for trainees. The additional exposure and requirements for Level III training will be addressed in a subsequent, separately published Advanced Training Statement.

The numbers of cases, procedures, and experiences recommended are based on published guidelines, competency statements, and the opinions of the members of the writing group. It is assumed that training is directed by appropriately-trained mentors in an ACGME-accredited program and that satisfactory completion of training is documented by the program director. The number and types of encounters and the duration of training required for each level of training are summarized in Section 4.

2. GENERAL STANDARDS

Optimal training in echocardiography relies on the interplay between the learner and the educational environment. Success depends on the background, abilities, and commitment of the trainee; the volume and variety of cases; the effectiveness of faculty; and the educational culture of the laboratory. The current trend to introduce the fundamental principles, indications, applications, and limitations of echocardiography into the education of medical students and residents is encouraged and will facilitate subsequent mastery of this discipline. In particular, experience at an early stage with hand-carried ultrasound (HCU) enhances the learning process and facilitates an understanding of cardiovascular anatomy and hemodynamics.

2.1. Faculty

The echocardiographic laboratory in which training of cardiovascular fellows is undertaken should be under the direct supervision of a full-time qualified director (or directors) who has achieved Level III training (1,2). Participation of additional full- or part-time faculty provides a diversity of experience and is highly desirable. Exposure by the trainee to faculty and sonographers with different strengths and interests ensures a range of experience and a broader base of knowledge.

2.2. Facilities and Equipment

To provide acceptable fellowship training in echocardiography, a laboratory must have equipment capable of providing comprehensive TTE and transesophageal echocardiography (TEE), including M-mode and 2D and 3D imaging, pulsed and continuous-wave Doppler echocardiography, tissue Doppler, stress echocardiography, and color-flow imaging. The laboratory environment should offer a broad range of clinical material. The laboratory should conform to continuing quality improvement guidelines (3) and ideally perform at least 2,000 echocardiographic studies per year to give the fellow an appropriate variety of experience. Accreditation of the laboratory through an organization such as the Intersocietal Accreditation Commission for Echocardiography (IAC Echocardiography) is strongly encouraged. Intraprocedural (including intraoperative) echocardiography and an exposure to adults with structural and congenital heart disease should be available.

A rich and diverse clinical milieu will provide an environment in which the echocardiographic findings can be correlated with other diagnostic data and patient outcomes. Access during echocardiography training to other imaging modalities provides an opportunity to understand the strengths and limitations of echocardiography relative to other techniques. At an early stage, the trainee should be exposed to quality improvement initiatives, structured reporting, process improvement, and appropriate use. For those fellows who plan to be involved in clinical research, formal training in modern research methodology, including biostatistics, clinical trial design, ethics, and grant writing, should be available.

3. TRAINING COMPONENTS

Specific requirements for echocardiographic examination of pediatric patients have been published elsewhere (2,4,5). Training guidelines in the present document are primarily directed to trainees performing echocardiographic examinations in adult patients with acquired and congenital heart diseases.

3.1. Didactic Program

Didactic instruction may occur in a variety of formats, including lectures, conferences, journal clubs, and clinical case conferences. A program of didactic instruction is intended to provide the trainee with an understanding of the basic principles and appropriate clinical application of echocardiography. It should incorporate relevant knowledge of cardiac embryology, anatomy, pathology, and physiology, and integrate clinical information gained from other imaging disciplines, such as cardiovascular computed tomography, cardiovascular magnetic resonance, angiography, and nuclear medicine. The program should also expose trainees to appropriate use criteria for ordering echocardiographic tests. With the increased role of echocardiography in guiding interventional procedures, a specific program of instruction in the intraoperative use of echocardiography and its role in guiding management of structural/arrhythmic heart disease should be available for the advanced trainee.

The precise format for best achieving these educational goals will vary from institution to institution; however, given the increasing clinical application of other imaging modalities within cardiology, it is recommended that a common element of any didactic program include specific multimodality imaging conferences that address the appropriate use of echocardiography in clinical decision making.

3.2. Clinical Experience

Echocardiography plays an important role in the diagnosis and treatment of a wide variety of acquired and congenital cardiac disorders. Accordingly, exposure to the entire spectrum of heart disease in a diverse patient population should be available to the trainee. Although a recommended number of clinical cases to encounter during training is provided (see Section 4.2), these criteria merely serve as proxies for clinical exposure. In terms of the overall quality of the educational experience and depth of understanding, the number of echocardiographic studies in which the trainee participates is less important than the range of pathologies encountered and adequacy of supervision and instruction. The criteria described herein are similar to those in other publications on this topic (1,2,6–9). If the case mix available for the trainee is skewed, additional cases beyond the numbers quoted may be required to ensure appropriate experience (10).

3.3. Hands-On Experience

The echocardiographic examination is an exceedingly operator-dependent procedure in which it is possible to introduce confounding artifacts or to omit data of diagnostic importance. The echocardiographic examination is interactive, requiring the real-time recognition of specific diagnostic findings to obtain a study that is of clinical

benefit. Therefore, fellowship training in echocardiography must emphasize the ability of the trainee to perform a hands-on examination independently with understanding of the results at the time of image acquisition. The trainee should develop sufficient technical skills in using an echocardiographic instrument to answer common clinical questions.

Such training is important not so much to develop true technical expertise as to better understand the diagnostic capabilities and potential pitfalls of the echocardiographic examination. It also helps trainees to learn tomographic cardiac anatomy and integrate planar views into a 3D framework. Highly skilled cardiac sonographers with broad experience in performing echocardiographic examinations are necessary to facilitate this training.

In contrast to transthoracic and stress echocardiography, which are most often performed by sonographers, advanced echocardiographic modalities, such as TEE and 3D echocardiography, require the trainee to acquire technical competency in image acquisition and image presentation. Clinical exposure to a broad range of cardiac pathologies and sufficient hands-on experience with the technology are essential for the advanced trainee to gain the requisite technical competency (see Section 4.2).

As part of the hands-on aspect of the echocardiographic training program, experience with HCU devices is desirable. These devices extend the clinical utility of echocardiography by allowing the operator to offer a "visual physical examination" in a manner that can be applied practically in the clinical setting (11). HCU devices offer capabilities similar to but less robust than their standard echocardiographic counterparts. Their appropriate application nevertheless requires that the operator have a fundamental understanding of echocardiographic principles, cardiac anatomy/physiology, and resultant echocardiographic correlates. Therefore, participation in a didactic echocardiographic educational program and hands-on training with conventional echocardiographic equipment best prepares the cardiovascular fellow to utilize HCU in the clinical setting as an adjunct to physical examination.

4. SUMMARY OF TRAINING REQUIREMENTS

4.1. Development and Evaluation of Core Competencies

Training and requirements for echocardiography address the 6 general competencies promulgated by the ACGME/ABMS 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 core 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 ACGME/ABIM reporting milestones. The ACC has adopted this format for its competency and training statements, career milestones, lifelong learning, and educational programs. Additionally, it has developed tools to assist physicians in assessing, enhancing, and documenting these competencies.

Table 1 delineates each of the 6 competency domains, as well as their associated curricular milestones for training in echocardiography. The milestones are categorized into Level I, II, and III training (as previously defined in this document) and indicate the stage of fellowship training (12, 24, or 36 months, and additional time points) by which the typical cardiovascular trainee should achieve the designated level. Given that programs may vary with respect to the sequence of clinical experiences provided to trainees, the milestones at which various competencies are reached may also vary. Level I competencies may be achieved at earlier or later time points. Acquisition of Level II skills requires additional training during the standard 3-year cardiovascular fellowship. Level III skills may be attained during the standard 3-year fellowship in a dedicated program focused on advanced cardiac ultrasound imaging or may be acquired during a period of additional training, typically for those fellows seeking multimodality imaging training. The table also describes examples of evaluation tools suitable for assessing competence in each domain.

4.2. Training Requirements

Echocardiography is integral to the practice of cardiology. Because of the fundamental and essential nature of the technique, all fellows should have the opportunity to achieve Level II competency, which would prepare them to perform and interpret echocardiograms independently. This varies from prior versions of COCATS in which Level II training was considered optional and was provided only to those fellows who desired such training.

Fellowship training in echocardiography should include instruction in the basic aspects of ultrasound such as the principles, technology, indications, and limitations of the techniques. Every trainee should be educated in the physical principles and instrumentation of ultrasound and in cardiovascular anatomy, physiology, and pathophysiology, both with regard to the cardiovascular system in general and in relation to the echocardiogram in particular. Trainees at all levels should perform the echocardiographic and Doppler examination to integrate their understanding of tomographic and 3D cardiac anatomy. Trainees should correlate the findings from the echocardiographic and Doppler examination with the results of other imaging modalities and physical

examination. The trainee should master the relationships between the echocardiographic findings and results of other cardiovascular tests, such as catheterization, angiography, magnetic resonance imaging, and electrophysiology. The trainee should also understand the impact of the results of the echocardiographic examination on the medical and surgical management of the patient.

Ultrasound imaging is an evolving technology experiencing continued improvement with an expanding list of clinical indications. Every cardiovascular fellow should become familiar with the technical performance, interpretation, strengths, multiple clinical applications, and limitations of 2D echocardiographic/Doppler technology. Level I fellows should also be familiar with the risks associated with intravenous administration of echocardiographic contrast agents and have a general understanding of their intended advantages to enhance image quality, particularly myocardial border definition.

Within the scope of fellowship training, this document defines 3 levels of training (**Table 2**). Level I training provides the basic or introductory exposure that should be achieved by most trainees over the first 2 years of fellowship. This entails understanding the basic principles, indications, appropriate use, applications, and technical limitations of echocardiography and the inter-relation of this technique with other diagnostic methods. All fellows should achieve Level I competency to perform and interpret basic echocardiographic studies in the context of managing their patients. This level of training does not qualify a trainee to perform echocardiography or to independently interpret complex echocardiograms or a full range of echocardiograms typically acquired in an echocardiography laboratory. The competencies developed as part of this level of exposure are described in **Table 1**.

Beyond the basic exposure provided by Level I training, most cardiovascular fellows should attain Level II competency. Level II training prepares the fellow to independently perform and interpret basic and comprehensive echocardiographic studies, including resting transthoracic M-mode, 2D, and Doppler examinations, stress, and TEE in adults. Familiarity with published appropriate use criteria (12) should begin during Level I training and continue throughout fellowship.

Advanced (Level III) expertise requires additional experience during and, in some cases, beyond the general 3-year cardiology fellowship to acquire specialized knowledge and competencies, including additional and more specialized training in various ultrasound procedures (i.e., transesophageal, stress, and intraoperative procedures). This level of training also prepares an individual to direct an academic echocardiography laboratory and pursue a research career in echocardiography. Fellows who wish to incorporate advanced clinical investigation in echocardiography or multimodality imaging should attain Level III competency in a program that meets requirements addressed in a subsequent, separately published Advanced Training Statement (formerly Clinical Competence Statement).

The requirements for each level of training are summarized in **Table 2**. In defining these levels, it is recognized that specifying the duration of training and number of procedures is both necessary and desirable. It should be emphasized, however, that the quality of experience, intensity of the educational environment, variety and complexity of cases, and commitment of both faculty and fellow are the primary determinants of the value of fellowship training. As such, training duration and procedure volume for each level are provided as a guide, and flexibility and the individual needs of the trainee must be considered as well.

4.2.1. Level I Training Requirements

Level I training typically requires 3 months of full-time training or its equivalent devoted to understanding functional anatomy and physiology in relation to the echocardiographic examination. The trainee should participate in the interpretation of a minimum of 150 complete (M-mode, 2D, and Doppler) examinations and personally perform 75 of these studies under the supervision of the laboratory director, designated faculty, and cardiac sonographers. The Level I trainee should be able to recognize common cardiovascular pathologic entities. During Level I training, initial exposure to TEE and other special procedures may be appropriate, but full competence in these areas requires additional training. No other clinical or service responsibility, other than required outpatient clinic and routine night call duties, should be expected of the trainee during the dedicated period of Level I training in echocardiography.

4.2.2. Level II Training Requirements

Level II training is intended to prepare trainees to perform and interpret both basic and complex echocardiograms independently. During Level II training, emphasis should be placed on the variety, quality, and completeness of studies; quantification in diagnostic studies; and correlation with other diagnostic and clinical results in a broad range of clinical problems. To accomplish this, the typical fellow will need an additional 3 months, or the equivalent, of full-time training, interpreting an additional 150 (300 total) complete ultrasound imaging and Doppler hemodynamic examinations. Of these, at least 75 (150 total) should be performed by the trainee under appropriate supervision. The fellow with Level II training should be able to perform an echocardiographic and Doppler study that is diagnostic, complete, and quantitatively accurate. Competence at this level implies sufficient experience to interpret echocardiographic examinations accurately and

TABLE 1 Core Competency Components and Curricular Milestones for Training in Echocardiography

Competency Component		Milestones (Months)			
MEDICAL KNOWLEDGE		**12**	**24**	**36**	**Add**
1	Know the physical principles of ultrasound and the instrumentation used to obtain images.	I			
2	Know the appropriate indications, including the appropriate use criteria, for: M-mode, 2-dimensional, and 3-dimensional transthoracic echocardiography; Doppler echocardiography and color-flow imaging; transesophageal echocardiography; tissue Doppler and strain imaging; and contrast echocardiography.		I		
3	Know the limitations and potential artifacts of the echocardiographic examination.	I			
4	Know the standard views included in a comprehensive transthoracic echocardiogram.	I			
5	Know the standard views included in a comprehensive transesophageal echocardiogram.		I		
6	Know the techniques to quantify cardiac chamber sizes and evaluate left and right ventricular systolic and diastolic function and hemodynamics.			II	
7	Know the characteristic findings of cardiomyopathies.		I		
8	Know the use of echocardiographic and Doppler data to evaluate native and prosthetic valve function and diseases.			II	
9	Know the echocardiographic and Doppler findings of cardiac ischemia and infarction, and the complications of myocardial infarction.		I		
10	Know the echocardiographic findings of pericardial disease, pericardial effusion, and pericardial constriction.		II		
11	Know the characteristic findings of basic adult congenital heart disease.			II	
12	Know the findings of complex/postoperative adult congenital heart disease.			III*†	III*
13	Know the techniques to evaluate cardiac masses and suspected endocarditis.		II		
14	Know the techniques to evaluate diseases of the aorta.		II		
15	Know the techniques to assess pulmonary artery pressure and diseases of the right heart.		II		
16	Know the use and characteristic findings in the evaluation of patients with systemic diseases involving the heart.		II		
17	Know the indications for, and the echocardiographic findings in, patients with known or suspected cardioembolic events.		II		
18	Know key aspects of contrast echocardiography including interpretation, administration techniques, and safety information.			II	
19	Understand the principles and applications of 3-dimensional echocardiography.		II		
20	Recognize and treat the potential complications of stress, contrast, and transesophageal echocardiography.		II		
	EVALUATION TOOLS: conference presentation, direct observation, and in-training examination.				
PATIENT CARE AND PROCEDURAL SKILLS		**12**	**24**	**36**	**Add**
1	Skill to perform and interpret a basic transthoracic echocardiographic examination.		I		
2	Skill to perform and interpret a comprehensive transthoracic echocardiographic examination.			II	
3	Skill to perform and interpret a comprehensive transesophageal echocardiographic examination.			II	
4	Skill to recognize pathophysiology, quantify severity of disease, identify associated findings, and recognize artifacts in echocardiography.			II	
5	Skill to integrate echocardiographic findings with clinical and other testing results in the evaluation and management of patients.		I		
6	Skill to interpret stress echocardiography.			II	
7	Skill to incorporate stress hemodynamic information in the management of complex valve disease or hypertrophic cardiomyopathy.			II	
8	Skill to utilize echocardiographic techniques during cardiac interventions, including intraoperative transesophageal echocardiography.			III†	III
9	Skill to perform and interpret basic 3-dimensional echocardiography.			II	
10	Skill to utilize advanced 3-dimensional echocardiography during guidance of procedures and/or surgery.			III†	III
11	Skill to perform and interpret contrast echocardiographic studies.			II	
	EVALUATION TOOLS: direct observation, logbook, and simulation.				

TABLE 1 Core Competency Components, continued

Competency Component		Milestones (Months)			
SYSTEMS-BASED PRACTICE		**12**	**24**	**36**	**Add**
1	Work effectively and efficiently with the echocardiography laboratory staff.	I			
2	Incorporate risk/benefit, safety, and cost considerations in the use of ultrasound techniques.			I	
3	Participate in echocardiographic quality monitoring and initiatives.			II	
	EVALUATION TOOLS: direct observation and multisource evaluation.				
PRACTICE-BASED LEARNING AND IMPROVEMENT		**12**	**24**	**36**	**Add**
1	Identify knowledge and performance gaps and engage in opportunities to achieve focused education and performance improvement.		I		
	EVALUATION TOOLS: conference presentation and direct observation.				
PROFESSIONALISM		**12**	**24**	**36**	**Add**
1	Know and promote adherence to guidelines and appropriate use criteria.		I		
2	Interact respectfully with patients, families, and all members of the healthcare team, including ancillary and support staff.	I			
	EVALUATION TOOLS: conference presentation, direct observation, multisource evaluation, and reflection and self-assessment.				
INTERPERSONAL AND COMMUNICATION SKILLS		**12**	**24**	**36**	**Add**
1	Communicate with and educate patients and families across a broad range of cultural, ethnic, and socioeconomic backgrounds.		II		
2	Communicate testing results to physicians and patients in an effective and timely manner.		II		
3	Communicate detailed information on cardiac anatomy for surgical planning or guidance of interventional procedures.			II	
	EVALUATION TOOLS: direct observation and multisource evaluation.				

*Because of its unique and specialized nature, competency in interpreting complex and postoperative congenital heart disease echocardiography studies will usually require training beyond Level II. †See definition of Level III training in Section 1.2.

Add = additional months beyond the 3-year cardiovascular fellowship.

independently. Continued experience in special echocardiographic procedures such as TEE, 3D, and stress echocardiography is appropriate during Level II training, but full competence to perform these techniques independently requires completion of Level II training and supervised performance of the requisite number of special studies. Additional guidelines for training in these areas are described later in this document. Gaining experience in the appropriate use of contrast and the role of echocardiography in congenital heart disease should also be part of Level II training. Additionally, Level II training should include recognition of the echocardiographic changes that can develop in highly conditioned athletes. This level of training is recognized by successful completion of a qualifying examination such as the National Board of Echocardiography examination.

4.2.3. Level III Training Requirements

Advanced expertise in echocardiography requires Level III training during, and in some cases, beyond the 36-month cardiovascular fellowship. To achieve Level III competency during a 3-year fellowship period, all available elective time must be devoted to echocardiography. Level III training is intended for those fellows who plan careers in echocardiography and should include exposure to echocardiographic laboratory administration, including quality improvement and the understanding and ability to incorporate new and evolving ultrasound technologies and applications. To obtain Level III competence, the trainee should fulfill all of the previously described requirements (including those delineated in **Table 2**) and develop additional experience in performing and interpreting special procedures, such as intraprocedural, 3D, strain, and contrast echocardiography in a program that meets requirements that will be addressed in a subsequent, separately published Advanced Training Statement (formerly a Clinical Competence Statement).

4.3. Training in Multiple Imaging Modalities

The recent emergence of other noninvasive imaging modalities, especially cardiovascular magnetic resonance and computed tomography angiography, is having a profound impact on the practice of cardiology and the fellowship training experience. The cardiovascular medicine specialist is increasingly expected to provide expertise in 2 or more imaging techniques. Trainees

TABLE 2 Summary of Training Requirements for Echocardiography

Level	Duration of Training* (Months)	Cumulative Duration* of Training (Months)	Minimal No. of TTE Examinations Performed	Minimal No. of TTE Examinations Interpreted	TEE and Special Procedures
I	3	3	75	150	Yes†
II	3	6	150 (75 Add)	300 (150 Add)	Yes‡
III	3	9	300 (150 Add)	750 (450 Add)	Yes

*Typical duration assuming acceptable progress toward milestones and demonstrated competency. †Exposure to TEE and other special procedures. ‡Completion of Level II and additional special training are needed to achieve full competence in TEE and other special procedures.

Add = additional; TEE = transesophageal echocardiography; TTE = transthoracic echocardiography.

should, therefore, gain exposure to multiple imaging modalities during the cardiovascular fellowship. To the degree possible, the training program should strive to meet these needs by offering multimodality imaging experiences (see COCATS 4 Task Force 4 report) that address each technique's uses and clinical indications, strengths and limitations, safety issues, and relevant guidelines and appropriate use criteria, when available.

4.4. Special Ultrasound Procedures

Special procedures are those that require specialized training. Exposure to these procedures may begin during Level I training, but competence requires at least completion of Level II and additional specialized training as described in the following text. Some are covered under Level II training, such as stress echocardiography, TEE, tissue Doppler, contrast echocardiography, and in some cases, intraoperative TEE. Others generally require Level III training, such as evaluation of advanced myocardial mechanics (strain echocardiography, dyssynchrony assessment), 3D echocardiography, epicardial and epivascular echocardiography, and echocardiography during catheter-based interventional procedures. Adequate training in special ultrasound procedures depends on a full understanding of the principles, indications, risks, and technical limitations of the techniques. In addition to special expertise, mastery of these procedures involves the ability to integrate the information from the procedures into clinical practice. Each special procedure can only be learned at a high-volume reference laboratory with an adequate volume of cases under the supervision of fully-qualified physician experts who perform and interpret a large number of the procedures annually according to specific guidelines applicable to the procedure. Specific recommendations for the various procedures follow.

4.4.1. Transesophageal Echocardiography

TEE is best learned in a laboratory that performs at least 500 TEE studies annually. Although the technical expertise needed to perform TEE may be acquired in a lower-volume setting, less volume limits exposure to the critical and unusual abnormalities uniquely identified by TEE. Training should include exposure to TEE examinations performed for a broad array of indications, including but not limited to assessment of native and prosthetic valve disease, aortic disease, acquired or congenital structural heart disease, and evaluation of masses (e.g., thrombus or vegetation). Minimum training for independent performance and interpretation of TEE requires performance of 25 esophageal intubations and 50 supervised complete multiplanar diagnostic studies (2); however, in many instances, this level of expertise will be inadequate to expose the trainee to the full range of pathologies encountered in the clinical practice of TEE. Therefore, continued instruction under the supervision of an experienced operator for an additional 50 studies is recommended. The growing availability of TEE simulation to supplement clinical experience will likely make this an increasingly important and practical way to enhance TEE skills.

Competence requires full knowledge of the indications, contraindications, and complications of TEE, which can be achieved through both experiential and didactic education. Independent performance of TEE also requires knowledge of and experience in the administration of conscious sedation. For most cardiovascular training programs, initial exposure to TEE can begin during Level I training, with competence in nonintraoperative TEE being a component of Level II training.

4.4.2. Intraoperative TEE

Intraoperative TEE requires training in routine TEE followed by additional experience evaluating patients undergoing a variety of cardiac procedures in the operating room (13,14). Experience in the operating room should involve the evaluation and monitoring of patients undergoing routine coronary bypass surgery, as well as the examination of patients during valve replacement and repair procedures. Published guidelines for training in intraoperative TEE (15) have been developed primarily for the cardiovascular anesthesiologist who has not had prior training in routine TEE. For cardiovascular fellows who have achieved Level II training in echocardiography (having performed at least 50 TEE studies), competency in intraoperative TEE requires a minimum of 100 additional intraoperative TEE studies supervised by a qualified expert. Competency in intraoperative TEE also requires an understanding of the cardiac surgical procedures, cardiopulmonary bypass, and intraoperative

changes in hemodynamics as assessed by echocardiography. Intraoperative monitoring of procedures for patients with congenital heart disease requires specific training that is often best acquired in a pediatric training laboratory (16).

4.4.3. Echocardiography During Interventional Procedures

Echocardiography plays an essential role in the selection of patients with structural heart disease for catheter-based interventions, planning for these procedures, and intraprocedural monitoring (17,18). Interventional procedures that are typically guided by echocardiography (transthoracic, transesophageal, or intracardiac) include, but are not limited to, transcatheter valve replacement or repair and closure of atrial or ventricular septal defects, perivalvular sources of regurgitation, and the left atrial appendage. Training should occur in a center that performs a high volume of interventional procedures for structural heart disease. There are currently no guidelines for training in echocardiographic guidance of interventional procedures, although there are courses of instruction on the echocardiographic guidance of transcatheter valve devices. A high level of expertise in probe manipulation and advanced understanding of cardiac anatomy related to echocardiographic imaging are vital for these procedures. Accordingly, guidance of interventional procedures requires Level III training and special competency in 3D echocardiography. Competency for independent performance is demonstrated by the ability to completely characterize the cardiovascular anatomy and hemodynamics relevant to each specific interventional procedure and to provide both immediate guidance to operators during device-related procedures and feedback regarding the satisfactory completion of the intervention.

4.4.4. Stress Echocardiography

Training in stress echocardiography entails exposure to a mix of exercise and pharmacological stress testing, including patient selection, stress modality selection, stress test supervision, and integration of all diagnostic information (19,20). Exposure to stress echocardiography may begin during Level I training; however, because of the difficulty in interpreting segmental wall-motion abnormalities developing during stress echocardiography, achieving basic competence in this area is an objective of Level II training and generally requires supervised interpretation of more than 100 stress echocardiographic studies. For competence and independence in stress echocardiography, additional training beyond Level II is recommended. In addition to supervised interpretation, the training experience should include both didactic and experiential training in the indications for stress echocardiography; the advantages, limitations, and risks of different stress imaging approaches; monitoring of the stress test; and integration of stress echocardiographic results in clinical cardiovascular medicine. For independent supervision and interpretation of stress echocardiography, training must include participation in and interpretation of a minimum of 100 stress echocardiograms under the supervision of a Level III-trained physician. Level III experience includes advanced training in and understanding of: 1) the application of stress echocardiography for evaluation of abnormal hemodynamic responses in patients with valvular heart disease such as aortic stenosis, mitral regurgitation, or mitral stenosis; 2) the role of stress echocardiography in evaluation of patients with hypertrophic cardiomyopathy and pulmonary hypertension; and 3) the use of stress echocardiography for assessment of myocardial viability (20).

4.4.5. Intracardiac and Intravascular Ultrasound

Intravascular ultrasound is a specialized procedure most often performed in conjunction with cardiac catheterization (21). It is increasingly used to guide interventional and electrophysiology procedures (22). This procedure requires close collaboration with the interventional cardiologist to ensure proper interpretation of all available imaging data. Because interpretation of these studies has the potential for immediate and significant impact on patient management, communication among involved parties is critical. Performance and interpretation of intravascular ultrasound requires specific, dedicated training in both image acquisition and interpretation in a high-volume laboratory. Training in intracardiac echocardiography should be part of Level III training, and the requisite skills can be obtained only in a reference laboratory where this examination is performed routinely.

4.4.6. Contrast Echocardiography

Contrast echocardiography is a broad discipline. Encapsulated microbubble contrast agents that are stable in the blood produce left-sided cavity opacification and can be helpful for identification of endocardial borders and detection of intracardiac thrombi and masses (23,24). The ability to supervise and interpret these studies is part of Level II training in a laboratory that routinely incorporates agitated saline contrast in the evaluation of patients with suspected right-to-left shunts or unexplained hypoxemia. Training in contrast echocardiography should include instruction on the composition and safety of microbubble contrast agents, contrast-specific imaging methods, indications and contraindications, and specific scenarios in which contrast is likely to add value. The individual completing Level II training should have the requisite skills to perform and interpret contrast-enhanced echocardiograms under the supervision of a Level III echocardiographer trained in contrast imaging. Level III competency in echocardiography

includes more extensive exposure to rest and stress contrast echocardiography as well as acquisition of advanced knowledge of microbubble administration protocols, physical principles of contrast signal generation, and specific machine settings to optimize image quality.

4.4.7. Three-Dimensional Echocardiography

Three-dimensional echocardiography is a technically complex modality that has an increasing role in characterizing structural heart disease and is also used in planning and guiding certain interventional and surgical procedures (25). Level II training in echocardiography should provide a basic understanding of the principles of 3D echocardiography and recognition of the clinical situations in which 3D representation can add incremental value over 2D imaging. Level II training should prepare fellows to apply 3D echocardiography appropriately and expose them to basic image acquisition and interpretation. Because of the evolving nature and complexity of 3D echocardiography, independent performance, processing, and interpretation of 3D echocardiography is part of Level III training under the supervision of a Level III expert.

Training should be performed in a laboratory in which 3D echocardiography is used in a variety of applications including, but not limited to, assessment of ventricular volumes, valvular heart disease, and atrial septal defects. Competence to perform 3D echocardiography independently requires demonstration of skills in image acquisition, image processing (3D image set manipulation and display), interpretation of 3D transthoracic and transesophageal echocardiograms, and accurate communication of findings.

4.4.8. Strain Echocardiography and Myocardial Mechanics

Advanced methods have been developed for echocardiographic assessment of global or regional myocardial function, regional timing of myocardial contraction, myocardial strain, strain rate, and deformation (26). Although these techniques are not part of routine diagnostic echocardiography, they enhance diagnostic capabilities and will likely play an increasing role in the future. Level II training in echocardiography should include knowledge of the principles and potential applications of strain echocardiography. Independent interpretation and proper use of strain or strain rate echocardiography requires Level III training under the supervision of an expert in a laboratory in which these procedures are routinely performed. Training includes instruction in the physical principles of imaging cardiac mechanics, image processing, and scenarios in which strain imaging may contribute to clinical care.

Echocardiographic assessment of ventricular dyssynchrony can contribute to understanding cardiovascular pathophysiology and causes of symptoms (26,27) and may have a role in selecting patients for resynchronization therapy. Training in echocardiographic assessment of ventricular dyssynchrony should be obtained in a reference laboratory in which this examination is routinely performed and should include instruction in echocardiography-based optimization of resynchronization of pacemakers.

5. EVALUATION OF COMPETENCY

Evaluation tools in echocardiography include direct observation by instructors, in-training examinations, case logbooks, conference and case presentations, multisource evaluations, trainee portfolios, simulation, and reflection and self-assessment. Acquisition and interpretive skills should be evaluated in every trainee. Interaction with other physicians, patients, and laboratory support staff; initiative; reliability; decisions or actions that result in clinical error; and the ability to make appropriate decisions independently and follow-up appropriately should be considered in these assessments. 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 (e.g., number of cases, diversity of referral sources, testing modalities, diagnoses, and findings). Every echocardiographic study should be justified, and during training fellows should be required to link each procedure to the corresponding appropriate use criteria indication/code in their log book. Trainees should be prepared to explain why a given echocardiographic test is better suited to the clinical question than another imaging option. Fellows should document clinical correlation with the other imaging, hemodynamic, invasive laboratory, surgical pathology, and outcomes data to enhance understanding of the diagnostic utility and value of various studies. Finally, experiences in echocardiography should be assessed against measures of quality with regard to test selection, performance, interpretation, and reporting (28,29) in the interest of appreciating the potential adverse consequences of suboptimal testing.

The ACC, American Heart Association, and ASE have formulated a clinical competence statement on the performance, interpretation, and reporting of ultrasound studies (2). Self-assessment programs in echocardiography are available through the ACCF and other organizations. Program directors and trainees are encouraged to incorporate these resources in the course of training. In addition, objective examinations have been created by the National Board of Echocardiography for physicians with Level II training who want to test and demonstrate their competency. To confirm competency, trainees should

strongly consider preparing for and taking the appropriate National Board of Echocardiography examination.

Under the aegis of the program director and director of each imaging laboratory, facility, or program, the faculty should record and verify each trainee's experiences, assess performance, and document 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 to identify areas in which additional focused training may be required.

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APPENDIX 1. AUTHOR RELATIONSHIPS WITH INDUSTRY AND OTHER ENTITIES (RELEVANT)—COCATS 4 TASK FORCE 5: TRAINING IN ECHOCARDIOGRAPHY

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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 authors' employment and reporting categories. To ensure complete transparency, authors' comprehensive healthcare-related disclosure information—including relationships with industry not pertinent to this document—is available in an online data supplement. Please refer to http://www.acc.org/guidelines/about-guidelines-and-clinical-documents/relationships-with-industry-policy for definitions of disclosure categories, relevance, or additional information about the ACC Disclosure Policy for Writing Committees.

ACC = American College of Cardiology.

APPENDIX 2. PEER REVIEWER RELATIONSHIPS WITH INDUSTRY AND OTHER ENTITIES (RELEVANT)—COCATS 4 TASK FORCE 5: TRAINING IN ECHOCARDIOGRAPHY

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ACC = American College of Cardiology; ASE = American Society of Echocardiography; VCU = Virginia Commonwealth University.

APPENDIX 3. ABBREVIATION LIST

ABIM = American Board of Internal Medicine

ABMS = American Board of Medical Specialties

ACC = American College of Cardiology

ACGME = Accreditation Council for Graduate Medical Education

ASE = American Society of Echocardiography

COCATS = Core Cardiovascular Training Statement

HCU = hand-carried ultrasound

HIPAA = Health Insurance Portability and Accountability Act

TEE = transesophageal echocardiography

TTE = transthoracic echocardiography