APPENDIX 2. PEER REVIEWER RELATIONSHIPS WITH INDUSTRY—ACCF 2008 RECOMMENDATIONS FOR TRAINING IN ADULT CARDIOVASCULAR MEDICINE CORE CARDIOLOGY TRAINING (COCATS 3)—TASK FORCE 3: TRAINING IN DIAGNOSTIC AND INTERVENTIONAL CARDIAC CATHETERIZATION

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**Task Force 4: Training in Echocardiography**

*Endorsed by the American Society of Echocardiography*

Thomas Ryan, MD, FACC, Chair
William F. Armstrong, MD, FACC, Bijoy K. Khandheria, MD, FACC (American Society of Echocardiography Representative)

Echocardiography is currently the most widely used imaging technique for assessing cardiovascular anatomy and function. Clinical application of ultrasound encompasses M-mode, two-dimensional (2D), pulsed, and continuous-wave Doppler and color-flow imaging. Echocardiography, like invasive catheterization, provides 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. Today, an echocardiography laboratory can appropriately be called an ultrasound imaging and hemodynamic laboratory.

Fellowship training in echocardiography should include instruction in the basic aspects of ultrasound, but only those fellows who go beyond the basic level are trained sufficiently for independent interpretation of echocardiographic studies.
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 be required to perform the echocardiographic and Doppler examination to integrate their understanding of three-dimensional (3D) cardiac anatomy. Trainees should be encouraged to correlate the findings from the echocardiographic and Doppler examination with the results of other imaging modalities and physical examination. The trainee should master the relation between the results of the echocardiographic examination and findings of other cardiovascular tests, such as catheterization, angiography, and electrophysiology. Exposure to computer sciences and bio-engineering may also be beneficial. The trainee should also master the relation between the results of the echocardiographic examination and surgical and medical management of the patient.

Every cardiology fellow should be exposed to and familiar with the technical performance, interpretation, strengths, and limitations of 2D echocardiographic/Doppler technology and its multiple clinical applications. It is recognized that ultrasound is an evolving technology, experiencing continued improvement, with an expanding list of clinical indications.

For appropriate use of this technology, it is possible to define 3 levels of expertise (Table 1). All cardiologists must attain at least the first level of expertise. This entails understanding the basic principles, indications, applications, and technical limitations of echocardiography and the interrelation of this technique with other diagnostic methods. This level will not qualify a trainee to perform echocardiography or to interpret echocardiograms independently. The second level of training in echocardiography should provide the knowledge and experience necessary to perform and interpret resting transthoracic M-mode, 2D, and Doppler examinations in adults independently under the supervision of a laboratory director. An exposure to or training in special echocardiographic procedures such as transthoracic echocardiography (TTE) and stress echocardiography can be undertaken as described later in this report. Gaining experience in the appropriate use of contrast and the emerging field of 3D echocardiography should also be a part of fellowship training. A third level of expertise would enable the trainee to direct an echocardiography laboratory and to gain additional expertise in various special ultrasound procedures (i.e., transesophageal, stress, and intraoperative procedures). Requirements for optimal training for these 3 levels differ and are addressed separately.

**General Standards**

Training in echocardiography should be integrated closely with the educational experience in cardiovascular catheterization and intervention, other noninvasive imaging modalities, surgery, and pathology. The echocardiographic laboratory in which training of cardiology fellows is undertaken should be under the direct supervision of a full-time qualified director (or directors) who has achieved Level 3 training (1,2). The training center should be a full-service laboratory that provides all modalities of echocardiography, including transthoracic, ambulatory, and intraoperative transesophageal echocardiography (TEE) and stress (exercise, pharmacologic, or both) echocardiography. Echocardiographic/Doppler examination in children or adults with congenital heart disease requires specific training at cardiology centers experienced in the management of these patients. Specific requirements for examination of pediatric patients have been published elsewhere (3–5). Training guidelines in the present document are primarily directed to trainees performing echocardiographic examinations in adult patients with acquired and congenital heart disease. A fully trained (Level 3) director of a laboratory should supervise the fellowship training program in echocardiography (1,2). Participation of additional full- or part-time faculty is highly desirable because of the multiple applications of echocardiography (i.e., transesophageal, stress, contrast, intraoperative, intravascular, 3D, and congenital).

The echocardiographic examination is an operator-dependent procedure in which it is possible to introduce confounding artifacts or omit data of diagnostic importance. Accordingly, the echocardiographic examination is interactive and requires the instantaneous recognition of normal variants and specific diagnostic findings to obtain an optimal study. Therefore, fellowship training in echocardiography must emphasize the ability to perform a hands-on examination independently with on-line interpretation of results. Hands-on training is important, not so much to develop true technical expertise but rather as a valuable aid to learn tomographic cardiac anatomy, integrate planar views into a

**Table 1 Summary of Training Requirements for Echocardiography**

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<th>Level</th>
<th>Duration of Training (Months)</th>
<th>Cumulative Duration of Training (Months)</th>
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*Exposure to TEE and other special procedures. †Completion of Level 2 and additional special training needed to achieve full competence in TEE and other special procedures. Add’l = additional; TEE = transesophageal echocardiography; TTE = transthoracic echocardiography.
3D framework, and understand the distinction between reliable and unreliable data. The trainee should develop sufficient technical facility to use an echocardiographic instrument to answer common clinical questions. To help with this training, availability of highly skilled cardiac sonographers with broad experience in the performance of the echocardiographic examination is desirable.

Content of the Training Program

Echocardiography plays an important role in the diagnosis and treatment of a wide variety of acquired and congenital cardiac disorders in a diverse group of patients. Accordingly, it is highly desirable that any laboratory in which cardiology fellows undertake echocardiographic training provide exposure to the entire spectrum of acquired and congenital heart diseases in patients of varying ages and both genders (6). Generally, such a laboratory should conform to continuing quality improvement guidelines (7) and perform at least 2000 echocardiographic studies per year, to give the fellow an appropriate variety of experience.

Although numbers of studies and time intervals of training are given as guidelines, these numbers are less important than depth of understanding and quality of the clinical experience. The number of echocardiographic studies in which the trainee participates is less important to the quality of the experience than the mix of patients and the range of diseases and pathology that he or she encounters. The criteria described herein are similar to those in other publications on this topic (1,2,8–11). If the case mix available for the trainee is skewed, additional numbers of cases beyond the criteria quoted herein may be required to achieve a broad spectrum of experience (12). It is recommended that fellows keep a logbook documenting their involvement in echocardiographic studies.

To provide acceptable fellowship training in echocardiography, a laboratory must have equipment with the capability for comprehensive TTE and TEE, including M-mode and 2D imaging, pulsed and continuous-wave Doppler echocardiography, and color-flow imaging. In this regard, 3D echocardiography is becoming increasingly prevalent and should be available in most modern training environments. The ability to complete adequate training in echocardiography will depend on the background and abilities of the trainee, as well as the effectiveness of the instructor and 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. The components and requirements of the 3 levels of training in clinical echocardiography are summarized in Table 1 and described in detail in the following text.

Level 1 Training (3 Months, at Least 75 Examinations Personally Performed, 150 Examinations Interpreted)

The first, or introductory, level requires 3 months of full-time training or its equivalent devoted to an understanding of functional anatomy and physiology in relation to the echocardiographic examination. During this time, 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. These initial training activities should take place under the supervision of the laboratory director, designated faculty, and cardiac sonographers. The Level 1 trainee should be able to recognize common cardiovascular pathologic entities. During Level 1 training, some initial exposure to TEE and other special procedures may be appropriate. However, 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 his or her 3 months of Level 1 training.

Level 2 Training (3 Months of Additional Training, at Least 75 Additional Examinations Personally Performed, at Least 150 Additional Examinations Interpreted)

During Level 2 training, emphasis should be placed on the variety, quality, and completeness of studies, on quantification in diagnostic studies, and on correlation with other diagnostic and clinical results in a broad range of clinical problems. To accomplish this, the fellow should devote an additional 3 months, or the equivalent, of full-time training, interpreting a minimum of 150 additional (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 who has accomplished Level 2 training should be able to perform an echocardiographic and Doppler study that is diagnostic, complete, and quantitatively accurate. Competence at this level implies that the trainee is sufficiently experienced to interpret the TTE examination accurately and independently. Continued exposure to special echocardiographic procedures such as TEE, 3D, and stress echocardiography is appropriate during Level 2 training. However, to become fully competent to perform these techniques independently, the completion of Level 2 training and the supervised performance of the required number of special studies is necessary.
Level 3 Training (6 Months of Additional Training, at Least 150 Additional Examinations Personally Performed, at Least 450 Additional Examinations Interpreted)

For a trainee desiring to direct an echocardiographic laboratory (Level 3), an additional 6 months (total of 12 months of training) devoted to echocardiography is required. To attain Level 3, the trainee should interpret a minimum of 450 additional complete imaging and hemodynamic studies (a total of 750 studies) and personally perform an additional 150 examinations (a total of 300) in a patient population in which a broad spectrum of adult acquired and congenital heart disease is present. The laboratory should conform to continuous quality improvement guidelines (8) and ideally perform at least 2000 echocardiographic studies per year to give the fellow an appropriate variety of experience. At the discretion of the director, increasing independence in interpretation and overreading of echocardiographic studies can be implemented. Level 3 training should also include exposure to administrative aspects of running an echocardiographic laboratory and documented experience in echocardiographic research, as well as understanding of new and evolving ultrasound technologies and applications of echocardiography. To complete Level 3, the trainee should fulfill all of the previously described requirements and develop competence in performing and interpreting special procedures, such as TEE, 3D, stress, and contrast echocardiography.

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 of the imaging techniques. It is understandable, then, that trainees will desire the opportunity to gain exposure to multiple imaging modalities during their fellowship experience. To the degree possible, the training program should strive to meet these needs by offering a “multimodality” imaging experience. This might include an appreciation for each technique’s uses and clinical indications, strengths and limitations, safety issues, and the guidelines and appropriateness criteria, when available.

Training for Physicians in Practice

It should be recognized how difficult it is to recreate the breadth and intensity of a training fellowship once an individual has assumed the full-time responsibilities of a practice setting. It may be possible to obtain the equivalence of Level 1 or 2 training outside the usual fellowship track through asiduous self-study, ongoing visits to training laboratories, and participation in continuing medical education. Key aspects of the training experience, however, may be impossible to replicate outside the fellowship environment. For the practicing physician interested in obtaining equivalent training, it is recommended that a mentoring relationship be established with a training laboratory whereby the physician works under the aegis of a Level 3-trained echocardiographer. In this situation, the numbers of cases required to achieve each level of training are similar to those listed in Table 1.

Ultrasound Special Procedures

Special procedures include but are not limited to exercise and pharmacologic stress, TEE (including intraoperative TEE), epicardial and epivascular echocardiography, intravascular echocardiography, intracardiac echocardiography, contrast echocardiography, echocardiography during interventional procedures (myocardial biopsy, pericardiocentesis, mitral balloon valvulotomy, or device closure of septal defects), and TTE in patients with complex congenital heart disease. Exposure to these procedures may begin during Level 1 training, but competence requires completion of Level 2 and additional specialized training as described in the following text. These examinations require special expertise, involve the management of high-risk patients, and often entail the performance of invasive ultrasound procedures in ways that cannot be repeated readily if the initial study is not diagnostic. As with any echocardiographic technique, adequate training in special ultrasound procedures is dependent on a full understanding of the principles, indications, applications, and technical limitations of these techniques. There is a certain procedure-specific learning curve to these advanced studies (13–15), which are best learned under the close supervision of a fully qualified expert in the particular ultrasound application. These more detailed procedures can only be learned by affiliation with a high-volume reference laboratory with adequate ongoing volumes in each of these modalities, under the tutelage of a designated physician-instructor who performs and interprets a large number of these special procedures annually (7,8). Specific recommendations for the various procedures are presented in the following text.

Transesophageal Echocardiography

Transesophageal echocardiography is best learned in a high-volume laboratory that performs at least 500 TEE studies per year. Although the technical expertise needed to perform TEE may be acquired in a lower-volume setting, the lower number of pathologic cases typically encountered in low-volume laboratories limits the trainee’s exposure to
critical and unusual abnormalities that are uniquely identified by TEE. Minimum training in TEE requires 25 esophageal intubations and 50 supervised diagnostic studies before independent interpretation (8). 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 training under the supervision of a more experienced operator for an additional 50 studies is highly recommended. For most cardiology training programs, initiation of the process of learning TEE should be undertaken only after completion of Level 1 training; exposure to TEE during Level 1 training is appropriate in some situations and laboratories. For full competence and independence in TEE procedures, additional special training is necessary. Competence in TEE also requires knowledge of and experience in the administration of conscious sedation.

**Stress Echocardiography**

For exercise and pharmacologic stress echocardiography, participation in a sufficient number (greater than or equal to 100) of supervised interpretations is the minimum requirement for the independent interpretation of stress echocardiograms (13,14). Exposure to stress echocardiography may begin during Level 1 training; however, because of the high level of difficulty in interpreting segmental wall-motion abnormalities in stress echocardiography, achieving basic competence in this area is an objective of Level 2 training and ideally entails supervised interpretations of far more than 100 stress echocardiography studies. For competence and independence in stress echocardiography, additional training beyond Level 2 is recommended. In addition to supervised interpretation, the training experience should include involvement in the selection of patients for the procedure; a thorough understanding of the advantages, limitations, and risks of each of the procedures; and monitoring of the actual stress test.

**Intracardiac and Intravascular Ultrasound**

Intravascular ultrasound is a specialized procedure that is most often performed in conjunction with catheterization. This requires close collaboration with the interventional cardiologist to ensure proper interpretation of all available imaging data. Because the 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 training in this technique from a standpoint of both acquisition and interpretation that can be obtained only through dedicated training in a high-volume intravascular catheterization setting. Intracardiac echocardiography is a newly developed ultrasound tool for which there are no specific pre-existing training guidelines. This procedure should be learned during or after Level 3 training in echocardiography, and the requisite skills can be obtained only in a reference laboratory in which this examination is performed on a routine basis.

**Intraoperative Transesophageal Echocardiography**

Intraoperative TEE requires background and experience in routine TEE followed by additional specific experience in the operating room evaluating patients undergoing a variety of cardiac procedures. Experience in the operating room is required before independent performance of intraoperative echocardiography, and this training should involve the monitoring of patients undergoing routine coronary bypass surgery, as well as the study of patients during valve replacement and repair procedures (15–17). This entails an understanding of and experience with the processes of cardiac surgery, cardiopulmonary bypass, and intraoperative changes in hemodynamics as they are assessed with echocardiography. Guidelines for training in intraoperative TEE have been developed and published (18). For basic training, a minimum of 150 complete examinations under appropriate supervision are required, of which at least 50 should be personally performed, interpreted, and reported. This level of experience is necessary for independent diagnostic expertise in this field. For advanced training, it is recommended that 300 complete examinations be undertaken, of which at least 150 are personally performed.

Intraoperative echocardiography is an area in which diagnostic conclusions have the potential for immediate major changes in patient management and outcome. A Level 3–trained echocardiographer needs to be a locus of knowledge with expertise in intraoperative echocardiography and may need to provide guidance and consultation to colleagues in anesthesia or surgery. Intraoperative monitoring of congenital heart disease procedures requires specific training that is best acquired in a pediatric training laboratory (16).

**Contrast Echocardiography**

Contrast echocardiography is a broad and evolving discipline. For simple applications, such as saline contrast injections to detect right-to-left shunts, it is appropriate to learn during Level 1 training in echocardiography. Currently available contrast agents allow left ventricular cavity opacification and can be helpful for identification of endocardial borders. Knowledge of contrast physics and additional experience in this technique should be part of Level 2 training. The individual completing Level 2 training should have the requisite skills to perform and interpret contrast-enhanced echocardiograms. Contrast echocardiography for this purpose is a technology- and machine-specific study. Thus, the trainee should have obtained special training in the instrumentation required for acquisition of high-quality contrast echocardiograms. Participation in a sufficient number (greater than or equal to 20) of supervised interpretations of contrast echocardiograms for left ventricular cavity opacification for endocardial border detection is the minimum requirement for independent interpretation.

Contrast echocardiography to assess myocardial perfusion is still in evolution and remains a complex technology-dependent
examination. The skills required for appropriate performance and interpretation of myocardial contrast echocardiography can be obtained only by association with a high-volume laboratory actively engaged in this technique. The individual who wishes to obtain training in myocardial contrast echocardiography must have a firm understanding of the physics and instrumentation technology needed to detect microbubbles within the coronary microcirculation and an understanding of the limitations of this technique. This can be obtained only by advanced training (within or beyond Level 3) in high-volume reference laboratories actively engaged in this procedure.

3D Echocardiography

Three-dimensional echocardiography has emerged as a clinically relevant, although technically complex, modality. As the technology continues to evolve, it will likely play an increasingly prominent role in echocardiographic diagnosis. Beginning in Level 2, the trainee should be exposed to 3D echocardiography, primarily to understand its growing role within the broader echocardiographic armamentarium. In order to develop true expertise in the instrumentation and techniques required for the acquisition and interpretation of 3D echocardiograms, Level 3 training is necessary.

Evaluation of Proficiency

Evaluation of competence is an integral and critical part of the educational process in echocardiography for a cardiology fellow. Optimal evaluation may be accomplished by direct observation of the ability of the trainee to perform and interpret the echocardiographic examination or may take the form of a practical or written examination, or both. It is recommended that such observational evaluation be done on a daily basis by the director of the laboratory or his or her associates and that it involve both hands-on and reading sessions. Evaluation of the competence of a cardiology fellow in echocardiography should be the responsibility of the director of the echocardiographic training laboratory and the director of the cardiology training program.

In addition, objective examinations have been created by the National Board of Echocardiography for physicians who want to test and demonstrate their proficiency in both general echocardiography and intraoperative echocardiography. Some third-party payers have already begun to propose limiting payment for echocardiographic services to those physicians with documented evidence of proficiency. Hence, it is recommended that all physicians who want to confirm their proficiency should strongly consider preparing for and taking the appropriate National Board of Echocardiography examination.

This is a revision of the March 2002 document that was written by Thomas Ryan, MD, FACC—Chair; William F. Armstrong, MD, FACC; Alan S. Pearlman, MD, FACC; and William J. Stewart, MD, FACC.

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TASK FORCE 4 REFERENCES


Key Words: ACCF Training Statement • COCATS 3 • transesophageal echocardiography • stress echocardiography.
### APPENDIX 1. AUTHOR RELATIONSHIPS WITH INDUSTRY—ACCF 2008 RECOMMENDATIONS FOR TRAINING IN ADULT CARDIOVASCULAR MEDICINE CORE CARDIOLOGY TRAINING (COCATS 3)—TASK FORCE 4: TRAINING IN ECHOCARDIOGRAPHY

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