

## Task Force 1: Training in Clinical Cardiology

Kenneth L. Baughman, MD, FACC, *Chair*

F. Daniel Duffy, MD, MACP (*American Board of Internal Medicine Representative*),

Kim A. Eagle, MD, FACC, David P. Faxon, MD, FACC (*Accreditation Council for Graduate Medical Education Representative*), L. David Hillis, MD, FACC,

Richard A. Lange, MD, FACC

The training experience in clinical cardiology is fundamental to the development of the specialist in cardiovascular medicine. It should provide a broad exposure to acute and chronic cardiovascular diseases, emphasizing accurate ambulatory and bedside clinical diagnosis, appropriate use of diagnostic studies, and integration of all data into a well-communicated consultation, with sensitivity to the unique features of each individual patient. Active participation in research projects will provide the trainee with further experience in critical thinking and in evaluating the cardiology literature. The knowledge, skills, and experience realized by this broad training are essential to providing a solid foundation in clinical cardiovascular medicine before trainees focus on more specialized areas, which, for some, may become the dominant feature of professional activity. Other goals should be to provide a broad clinical background with an emphasis not only on pathophysiology, therapeutics, and prevention but also on the humanistic, moral, and ethical aspects of medicine. Although high levels of skills in diagnostic and therapeutic techniques are essential, the fundamental requirement for broad clinical insight needed by the consultant in cardiovascular medicine should be emphasized.

### General Aspects of Training

#### Training Institutions

Programs of training in cardiology must be accredited and offered only in university or university-affiliated institutions that have a residency training program in internal medicine and in cardiovascular disease. The program should be fully accredited by the Accreditation Council for Graduate Medical Education (ACGME) or the American Osteopathic Association.

#### Prerequisites for Training

Training in cardiology should almost always occur after successful completion of postdoctoral education and training in internal medicine. One exception relates to medical residents on the American Board of Internal Medicine (ABIM) Re-

search Pathway, which entails 2 years of internal medicine training followed by 2 years of clinical training in a subspecialty and 3 years of research training which includes an additional 10% clinical training ([www.abim.org](http://www.abim.org)).

#### Objectives of Training

The general principles enumerated in the institutional and program requirements for residency education in internal medicine (1–4) are also applicable to training in cardiology. (See the World Wide Web site [www.acgme.org](http://www.acgme.org) for ongoing updates of program requirements.) Cardiology training programs must provide an intellectual environment for acquiring the knowledge, skills, clinical judgment, attitudes, and values that are essential to cardiovascular medicine consistent with the 6 core competencies delineated by the ACGME (medical knowledge, patient care, interpersonal and communication skills, professionalism, practice and learning, and improvement and systems-based practice). Fundamental to this training is the provision of the best possible care for each individual patient delivered in a compassionate manner. All physicians undergoing training in cardiology must have and maintain humanistic and ethical attributes (1–7). The objectives of a training program in cardiology can be achieved only when the program leadership, supporting staff, faculty, and administration are fully committed to the educational program and when appropriate resources and facilities are present. Effective graduate education requires an appropriate balance between academic endeavors and clinical service. During training in cardiology, faculty should encourage trainees to cultivate an attitude of scholarship and dedication to continuing education that will remain with them throughout their professional careers. The development of a scholarly attitude includes active participation in and completion of 1 or more research projects supervised by faculty actively engaged in research, ideally followed by publication in critically reviewed journals. These activities will provide additional experience in critical thinking and will help develop an attitude of scholarship and greater insight into the problems of analyzing and reporting data and other observations obtained from patients. Critical thinking is also developed

in such educational activities as journal clubs, literature reviews, use of the Internet for self-directed learning, and the presentation of talks in seminars or conferences.

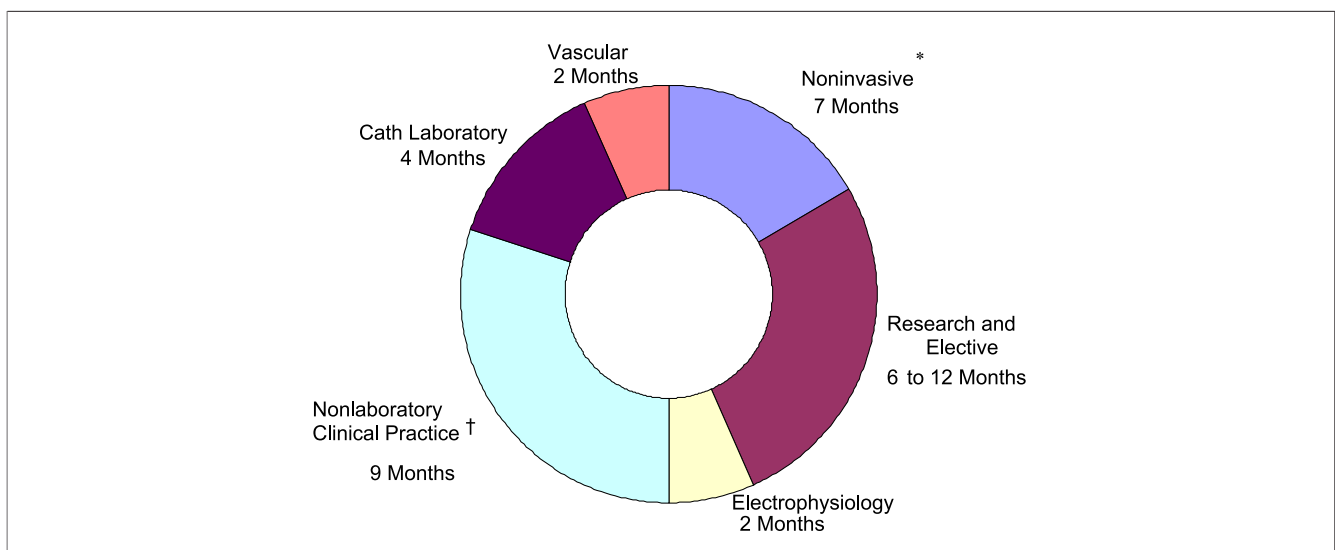
### Role of the Specialist and Duration of Training

Training in cardiology must take into account the role that the cardiovascular specialist is likely to play in the health care delivery system of the future. As a consequence of the aging of the population, the demand for cardiovascular care will increase. Cardiovascular specialists will have to serve as expert consultants and procedural specialists, and the training must reflect this expanded role.

The rotations of fellows in training for cardiovascular disease must be determined by the curriculum that is needed to permit fellows to develop requisite competencies, not by the needs of the training facility or the training program faculty. The 3-year training program should include a clinical core of 24 months with the following minimums: 1) 9 months in nonlaboratory clinical practice activities (e.g., cardiac consultation, inpatient cardiac care, intermediate acute care unit, chest pain unit, coronary care unit, cardiothoracic/cardiovascular surgery, congenital heart disease, heart failure/cardiac transplantation, preventive cardiovascular medicine, cardiac rehabilitation, and vascular medicine); 2) 4 months in the cardiac catheterization laboratory; 3) 7 months in noninvasive imaging (echocardiography and Doppler [minimum 3 months], noninvasive and peripheral vascular studies, and nuclear cardiology techniques [minimum 2 months]) and cardiovascular magnetic resonance and other techniques (e.g., electron beam or fast helical computed tomography); 4) 2 months (in blocks or equivalent experience) in electrocardiography, stress testing, and ambulatory electrocardiographic

monitoring; and 5) 2 months in arrhythmia management, permanent pacemaker and implantable cardioverter-defibrillator management, and electrophysiology; 2 months in the recognition and management of patients with peripheral vascular disease. A continuing ambulatory care experience should be provided for at least one-half day per week throughout the 3-year training program (Fig. 1). Trainees who elect to extend their fellowship training to 4 years by performing 1 additional year of research may receive 1 month only of credit for clinical consultation training by extending their ambulatory care experience for one-half day per week for at least 48 weeks during that year. No other clinical curricular activities may be performed during this time, and a maximum of 1 month of credit is allowed regardless of duration of continuity outpatient clinical experience during research years. An option for fellows undertaking 2 years of research training is to conduct a continuity clinic every other week for the 2-year period. This would be equivalent to having a weekly clinic for 1 of the 2 research years. If a fellow moves to another institution for a year of research training as part of a 3-year fellowship program, a comparable outpatient clinic experience can be undertaken at the second institution.

These time periods are considered to be the minimal time required to learn the indications, interpretative skills, knowledge of complications, risk/benefit, and cost/benefit of these procedures. This core 24-month training period does not qualify a trainee as a consultant in cardiovascular disease or as an expert in these technical procedures. Expertise in interventional cardiology, electrophysiology, heart failure/transplantation, and cardiovascular research require additional training beyond the standard 36-month fellowship.



**Figure 1** COCATS 3-Year Cardiovascular Fellowship Level 1 Exposure

This represents outpatient exposure at one-half day per week. Electrocardiogram, ambulatory electrocardiogram, and exercise testing may be fulfilled in 24 to 36 months. \*Includes echocardiography, nuclear cardiology, cardiovascular magnetic resonance, and cardiovascular computed tomography. †May include cardiac failure and preventive cardiovascular medicine.

The remaining year in the program should include dedicated research. In addition, trainees should be exposed to a curriculum throughout fellowship training that includes biostatistics, epidemiology, design and conduct of research trials, and a critical review of the medical literature. The remaining months of training may include the acquisition of more intensive training in specific areas of cardiovascular medicine or continued research. Trainees often require additional clinical training to be qualified to function properly as consultants in cardiovascular disease and as specialists in cardiology. This latter period permits the trainees to obtain greater experience and supervised training in the clinical management of patients with cardiovascular disease and to obtain additional training in the performance and application of particular diagnostic or therapeutic procedures. Trainees planning an academic career usually need additional research training (see Appendix 1). Vacation time, as well as time for participation in professional meetings and conferences, will be allotted in a manner compatible with institutional policy. Vacation time will be taken proportionately during the clinical core and research elective experience.

### **Program Faculty**

The program must be conducted under the auspices of a program director who is highly competent in the specialty of cardiovascular disease and fully committed to the training of the cardiovascular specialist. The program director must have experience as a faculty member in an active and accredited cardiology residency program. The director of the cardiology training program must be certified by the ABIM Subspecialty Board on Cardiovascular Disease or possess appropriate educational qualifications. The director should participate in scholarly activity (e.g., peer-reviewed publications, grants, and review articles). The director is responsible for ensuring the adequacy of the training facility, including support resources for the provision of an education of high quality.

There should be 1 full-time program faculty member for every 1.5 trainees in the division (or section) of cardiology to guarantee close supervision of all trainees and to allow for critical evaluation of the program and the competence of the trainees. Each rotation and laboratory should have faculty members who supervise the fellows. It is essential that the cardiology program director devote sufficient time and effort to the graduate education program and related activities. Cardiology program directors must be full-time faculty members. The program director must have the effective support of the institution(s) where the training takes place to provide these educational attributes.

## **Environment for Training in Clinical Cardiology**

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### **Interaction With Other Disciplines**

Cardiology training programs must provide an intellectual environment for acquiring the knowledge, skills, clinical judgment, and attitudes that are essential to the practice of cardiovascular medicine. Specialists in cardiovascular disease must interact with generalists and specialists in other areas and have knowledge of other specialties to provide excellent patient care. The ACGME requires at least 2 other subspecialty training programs in internal medicine and a residency in internal medicine in order to enable the cardiovascular disease trainee to collaborate with other disciplines by providing consultations and participating in co-management of suitable patients. Close interaction with cardiovascular/cardiothoracic surgery is of particular importance. The overall program must provide advanced training to allow the physician to acquire expertise as a specialist and consultant in cardiology.

### **Relation to Training in Internal Medicine**

Cardiology training programs must provide the opportunity for cardiology trainees to maintain their skills in general internal medicine and in those aspects of cardiology that relate to internal medicine. Therefore, the cardiology program must be closely related to the training program in internal medicine, and there must be carefully delineated lines of responsibility for the residents and staff in internal medicine and the cardiology trainees. Trainees should maintain close working contact with residents and fellows in other areas, including surgery, critical care medicine, anesthesia, radiology, pulmonary disease, pathology, pediatrics, and neurology. When appropriate, expert faculty in these disciplines should teach and supervise the trainees.

### **Required Training Program Resources**

The program must have certain minimal resources, including the following:

1. There must be inpatient and outpatient facilities with an adequate number of patients of a wide age range with a broad variety of cardiovascular disorders. Trainees must be supervised and evaluated on every rotation by qualified faculty members when they see patients in both areas. Outpatient care must be carefully supervised by faculty members.
2. The facility must provide laboratories for cardiac catheterization, electrocardiography, exercise and pharmacologic stress testing, Doppler/echocardiography, ambulatory ECG monitoring, and noninvasive peripheral vascular studies. There must be appropriate facilities for cardiac catheterization, angiography, and hemodynamic assessment, with adequate numbers of patients undergoing percutaneous interventional procedures

- (i.e., coronary angioplasty or stent placement), myocardial biopsy, and intra-aortic balloon placement (see the Task Force 2, 3, and 4 reports).
3. Facilities for nuclear cardiology must be available, including ventricular function assessment, myocardial perfusion imaging, and studies of myocardial viability (see the Task Force 5 report).
  4. There must be appropriate facilities for the management of patients with arrhythmias, including electrophysiologic testing, arrhythmia ablation, and signal-averaged electrocardiogram (ECG) and tilt-table testing, as well as the previous evaluation, implantation, and assessment of patients with cardiac pacemakers and implantable antiarrhythmic devices and their long-term management (see the Task Force 6 report).
  5. Facilities and faculty for training in cardiovascular research, including various basic science, clinical science, and population science modalities, are important (see the Task Force 7 report).
  6. Modern intensive cardiac care facilities must be available.
  7. Facilities for cardiac and peripheral vascular surgery and cardiovascular/cardiothoracic surgical intensive care must be provided at the primary site of training. Close association with and participation in a cardiovascular/cardiothoracic surgical program is an essential component of the cardiovascular training program. This must include active participation in the pre- and post-operative management of patients with cardiovascular disease. Exposure to cardiac transplantation is strongly recommended (see the Task Force 8 report).
  8. Facilities and faculty must be involved in the diagnosis, therapy, and follow-up care of patients with congenital heart disease (see the Task Force 9 report).
  9. There must be appropriate facilities for the clinical and laboratory assessment of patients with systemic hypertension and peripheral vascular disease (see the Task Force 10 and 11 reports).
  10. Facilities for assessment of cardiopulmonary and pulmonary function, cardiovascular radiography, and magnetic resonance imaging and computed tomography must be available (see the Task Force 12 report).
  11. Appropriate expertise and instruction in preventive cardiovascular medicine and risk-factor modification, including management of lipid disorders, must be provided (see the Task Force 10 report).
  12. There must be facilities for and faculty with knowledge of cardiovascular pathology.
  13. There must be facilities for and personnel and faculty with expertise in cardiac rehabilitation.
  14. Other appropriate facilities and resources necessary to accomplish the training must be provided, including a comprehensive medical library, facilities for continuing medical education, and a curriculum that includes experimental study design, statistics, and quality assurance.

## Training Components

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An educational clinical cardiovascular disease training program must have the following training objectives and characteristics and must encompass the following areas.

### Training in Patient Care and Management

In addition to the core clinical skills of internal medicine, all cardiology trainees must be skilled in obtaining a history and performing a complete cardiovascular physical examination. All trainees must be familiar with the role of aging and psychogenic factors in the production of symptoms and the emotional and physical responses of patients to cardiovascular disease. They must be familiar with the importance of preventive care and rehabilitative aspects of the management of patients with known or potential cardiovascular disease. The trainee should have considerable experience acting as a consultant to other physicians and should have direct, supervised patient care responsibility in proportion to his or her experience and qualifications. Extensive outpatient training is essential for learning the long-term course of patients with chronic cardiovascular disease.

### Training in Understanding, Diagnosis, Prevention, and Treatment of Cardiovascular Disease

The trainee must become well educated in pathogenesis, pathology, risk factors, natural history, diagnosis by history, physical examination and laboratory methods, medical and surgical management, complications, and prevention of cardiovascular conditions including coronary artery disease, hypertension, hyperlipidemia, valvular heart disease, congenital heart disease, cardiac arrhythmias, heart failure, cardiomyopathy, involvement of the cardiovascular system by systemic disease, infective endocarditis, diseases of the great vessels and peripheral blood vessels, diseases of the pericardium, pulmonary heart disease, the interaction of pregnancy and cardiovascular disease, cardiovascular complications of chronic renal failure, traumatic heart disease, and cardiac tumors and cardiovascular changes associated with advancing age. Cardiology trainees must develop an understanding of the various roles of collaboration, co-management, and consultation in the system-based care of patients with complex comorbidity and cardiovascular disease.

### Training in Intensive Care

The training must include at least 3 months of full-time experience with patients undergoing intensive care for acute cardiovascular disorders and coronary care. This exposure should include (but is not limited to) management of acute coronary syndromes, ST-elevation myocardial infarction, cardiogenic shock, acute decompensated congestive heart failure, symptomatic arrhythmias, hypertensive crisis, infective endocarditis, aortic dissection, pericardial tamponade, and pulmonary embolism. Appropriate use of hemodynamic monitoring;



intra-aortic balloon counterpulsation; and thrombolytic, percutaneous, and surgical therapy should be emphasized. In addition, because of the additional medical comorbidities that acutely ill cardiovascular patients manifest, trainees should gain additional expertise with airway and ventilator management, use of renal replacement therapy, and treatment of sepsis and other infectious complications.

### **Training in Ambulatory, Outpatient, and Follow-Up Care**

Continued responsibility for principal care, co-management with primary care physicians, and consultation outpatient cardiovascular patient management must occupy at least one-half day per week for 36 months. An ambulatory continuity clinic is essential for the duration of training. There should be exposure to a wide age range of patients, from adolescence through old age, with a spectrum of cardiovascular diagnoses, including post-operative patients, patients with congenital heart disease, and patients for evaluation and management related to pregnancy. Additional ambulatory experience in specialty clinics or hospital-based settings is desirable and may include participation in same-day diagnostic or therapeutic procedures.

### **Training in Electrocardiography**

All cardiovascular trainees must be skilled in the interpretation of ECGs. There must be appropriate review, audit, and evaluation of their skills. All cardiology trainees must be skilled in the performance and interpretation of exercise ECG tests and ambulatory and signal-averaged ECGs, as described in the Task Force 2 report.

### **Training in the Cardiac Catheterization Laboratory**

The trainee must have direct, supervised experience in a general adult cardiac catheterization laboratory that performs catheterizations of both the right and left sides of the heart. This initial experience in the cardiac catheterization laboratory must emphasize the fundamentals of cardiovascular physiology as it relates to clinical disease, the analysis of hemodynamic records, and the interpretation of angiographic images. Such an experience must also emphasize the problems in interpretation and analysis of such data and the importance of quality. All fellows must have adequate training in the principles of radiation safety. The amount of training in the mechanical skills of cardiac catheterization that is necessary is addressed in the Task Force 3 report. The acquisition of advanced procedural skills is not the primary purpose of the initial exposure of the trainee to the cardiac catheterization laboratory. All trainees must understand indications, risks, and benefits of interventional therapeutic procedures, as described by the Task Force 3 report.

### **Training in Echocardiography**

All trainees must participate in the performance of echocardiography and Doppler echocardiography and must understand the indications, risks, and benefits of transesoph-

ageal and stress echocardiography, as well as the principles of evolving techniques, such as intravascular ultrasound. Those trainees who wish to perform these latter techniques or to direct an echocardiography laboratory must have additional training, as described in the Task Force 4 report. The duration of exposure or number of procedures to achieve levels of training are outlined in the Task Force 4 report.

### **Training in Nuclear Cardiology**

All trainees should know the general principles, indications, risks, and benefits of nuclear cardiovascular procedures, such as radionuclide ventriculography and myocardial perfusion and viability assessment. All trainees must receive basic training in radiation safety. Trainees need a minimum of 2 months of training; those who wish to practice nuclear cardiology must have additional training, as described in the Task Force 5 report.

### **Training in Other Advanced Imaging Techniques**

All trainees should be aware of and preferably directly exposed to major evolving advanced imaging techniques.

### **Training in Cardiac Arrhythmia Device Management**

All trainees must understand the diagnosis and management of cardiac arrhythmias. Trainees should know the indications for cardiac arrhythmia devices and the principles of management and follow-up of patients with implanted pacemakers and antiarrhythmic devices, as described in the Task Force 6 report. Participation in implantation is desirable.

### **Training in Electrophysiology**

All trainees must be skilled in the selection of patients for specialized electrophysiologic studies, including arrhythmia ablation. Those who wish to perform these procedures should receive additional training, as described in the Task Force 6 report.

### **Training in Cardiovascular Research**

All trainees should participate actively in research activities. Trainees who anticipate a career in academic cardiology should have additional specialized training, as described in the Task Force 7 report. All trainees should understand clinical study design, biostatistics, and how to critically read and interpret the cardiovascular literature.

### **Training in Heart Failure and Heart Transplantation**

All trainees must understand the diagnosis and management of patients with heart failure and that of cardiac transplant recipients, as described in the Task Force 8 report.

### **Training in Congenital Heart Disease in the Adult**

All trainees must understand the diagnosis and management of adult patients with and without surgical repair of

congenital heart disease, as described in the Task Force 9 report. Trainees must participate in the transition of care of patients from pediatric to adult cardiologists.

### Training in Preventive Cardiovascular Medicine

All trainees should know the principles of preventive cardiovascular medicine, including vascular biology, genetics, epidemiology, biostatistics, clinical trials, outcomes research, clinical pharmacology, behavior change, and multidisciplinary care as described in the Task Force 10 report. Specific knowledge in the areas of hypertension, dyslipidemia, thrombosis, smoking cessation, cardiac rehabilitation, exercise physiology, nutrition, psychosocial issues, metabolic disorders, gender and racial issues, and aging is essential. Ideally, training should be undertaken in a 1-month (or longer) rotation. Those who will focus their clinical practice in preventive cardiovascular medicine should develop expertise in counseling for behavior change.

### Training in Vascular Medicine

The trainee must develop sound knowledge of the clinical features and treatment of vascular disease, demonstrate competence in obtaining the history and performing the physical examination of the arterial and venous systems, and become knowledgeable in the interpretation and selection of patients for noninvasive vascular tests and peripheral angiograms.

### Training in Magnetic Resonance Imaging

Familiarity with the cardiovascular applications and interpretations of magnetic resonance images is essential to the training of a cardiovascular fellow. This imaging modality has many existing uses and considerable potential in noninvasive diagnosis. The fellow should supplement this experience with exposure to cardiovascular magnetic resonance (CMR) studies throughout the clinical training program. Those who wish to interpret CMR studies or who desire advanced training must have additional training as designated in the Task Force 12 report.

### Training in Computed Tomography

Computed tomography (CT) is a rapidly evolving technique to evaluate cardiovascular anatomy and function. Clinical applications include noncontrast CT for coronary calcification, contrast CT to assess coronary anatomy and left ventricular function, and hybrid procedures combining CT with other noninvasive techniques. By the end of fellowship the trainee should be expected to have participated in 50 mentored interpretations to achieve Level 1 competency. See the Task Force 13 report for details.

### Training in Related Sciences

The training program should provide an opportunity for continuing education in basic sciences, including those aspects of anatomy, physiology, pharmacology, pathology, genetics, biophysics, and biochemistry that are pertinent to cardiology, particularly vascular biology, thrombosis, and

molecular biology. It is essential for trainees to acquire a thorough understanding of the normal physiology of the circulatory system, including the adaptation of the cardiovascular system to exercise, stress, pregnancy, aging, and renal and pulmonary abnormalities, and trainees must be able to reliably interpret tests of renal and pulmonary function. Learning in pharmacology should recognize dietary, renal, and hepatic function as well as geriatric influence on drug therapy. Complementary medicine as it affects traditional cardiovascular therapy should be included in the curriculum. The availability of educational programs in biostatistics, computer sciences, and biophysics is highly desirable. Training in medical economics, health care systems delivery, clinical decision making, preventive medicine, and health care outcomes should also be available.

### Training in Related Fields of Medicine

The trainee must gain knowledge and experience in a number of related areas of medicine, including the following:

1. *Radiology*: the interpretation of cardiovascular X-ray films, with particular reference to vascular structures and special cardiovascular radiologic procedures.
2. *Surgery*: the risks and benefits of cardiothoracic and cardiovascular surgery and the rationale for the selection of candidates for surgical treatment, as well as the natural history and the pre- and post-operative management of patients with cardiovascular disease and various co-morbid conditions.
3. *Anesthesia*: close collaboration with anesthesia colleagues in the pre- and post-operative management of patients with cardiac disease for cardiac and noncardiac surgery, as well as cardiac procedures that require anesthesia (e.g., cardioversion).
4. *Pulmonary disease*: a solid knowledge of basic pulmonary physiology in addition to the interpretation of pulmonary and cardiopulmonary function testing, blood gases, pulmonary angiography, and radiology lung scanning methods, as well as experience with management of patients with acute pulmonary disease.
5. *Obstetrics*: a solid knowledge of the inter-relationships between pregnancy and heart disease, together with experience in the clinical management of patients with heart disease who are pregnant, and safety of cardiovascular drug use in pregnancy.
6. *Physiology*: the physiology of the cardiovascular system, its response to exercise and stress, and the alterations produced by aging and disease.
7. *Pharmacology*: the pharmacology and interactions of cardiovascular drugs and drugs that affect cardiovascular function.
8. *Pathology*: familiarity with the gross and microscopic pathology of all major forms of heart disease.
9. *Geriatrics*: familiarity with the effects of aging on cardiovascular disease and therapy.

### Training Through Conferences, Seminars, Review of Published Reports, and Lectures

There must be regularly scheduled cardiology conferences, seminars, and reviews of published data. The participation of trainees in the planning and production of these conferences is expected. Attendance at medical grand rounds and multidisciplinary conferences is highly desirable, particularly at conferences closely related to cardiovascular disease, such as conferences on surgery, radiology, and pathology. Visiting professors should provide stimulation and at least informal evaluation and feedback to trainees and faculty.

### Teaching and Educational Experience

The trainee must participate directly in the teaching of cardiology to peers, internal medicine residents, and to referring physicians and become familiar with the fundamental principles of education, including skills in organization of conferences, lectures, and teaching materials. The teaching experience, often through weekly or more frequent core content conferences, must attempt to integrate basic biomedical information with the clinical aspects of cardiology, including integration of clinical management principles. Trainees must be familiar with modern concepts of education and effective communication. They must be responsible for teaching residents in internal medicine, as well as medical students, cardiology trainees, and allied health personnel, and for working collaboratively with other health care professionals. They must have regularly scheduled experiences in teaching and must be encouraged to attend and participate in national cardiology meetings. Trainees must learn to prepare successfully, through self-study and participation in continuing education using various media, for certification, recertification, and credentialing.

### Special Procedural Areas

In specific procedural areas of cardiology, minimal training is appropriate for physicians who do not plan to achieve additional qualifications in a given field. Conversely, those physicians who wish to become qualified in specialized areas require additional training, as specified by the individual task forces. Trainees should log all appropriate procedures.

### Evaluation and Documentation of Competence

The evaluation of trainees for both clinical and specialized technical skills must be documented carefully. Cardiology program directors must establish procedures for the regular evaluation of the clinical competence of cardiology trainees. This evaluation must include intellectual abilities, manual skills, attitudes, and interpersonal relations, as well as specific tasks of patient management, clinical skills (including decision-making skills), and the critical analysis of clinical situations. There must be provision for appropriate

feedback of this information to the trainee at regular intervals. Records must be maintained of all evaluations and of the number and type of all laboratory procedures performed by each trainee. The use of examinations (e.g., the Adult Clinical Cardiology Self-Assessment Program [ACCSAP]) at the end of each year of training or upon completion of each specialized area of training is strongly encouraged.

Attainment of core competences (medical knowledge, patient care, interpersonal and communication skills, professionalism, practice and learning and in applying the principles of quality measurement and improvement in their practice) must be documented. They should measure their clinical performance and participate in practice-based learning collaboratives, apply root-cause analysis to sentinel errors, develop improvement plans, and participate in the quality improvement activities of the institution.

*This is a revision of the 2002 document that was written by Kenneth L. Baughman, MD, FACC—Chair; Charles L. Curry, MD, FACC; David C. Leach, MD (American Council for Graduate Medical Education Representative); Prediman K. Shah, MD, FACC; and Laura F. Wexler, MD, FACC (American Board of Internal Medicine Representative).*

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**Key Words:** ACCF Training Statement ■ COCATS 3 ■ clinical cardiology ■ training requirements.

**APPENDIX 1. SUMMARY OF TRAINING REQUIREMENTS**

Task Force	Area	Level	Minimal Number of Procedures	Cumulative Duration of Training (Months)	Minimal Cumulative Number of Procedures	Comments
1	Clinical cardiology	1		36		
2	Electrocardiography	1	3500*†	36	3500	*Can be taken throughout the training program. †The committee strongly recommends that cardiologists achieve Level 2 training in ECG interpretation.
		2	3500			
	Ambulatory monitoring	1	150*	150	*Can be taken throughout the training program.	
		2	75	225		
	Exercise testing	1	200*	200	*Can be taken throughout the training program.	
		2	100	300		
3	Diagnostic catheterization	1	100	4	100	
		2	200	8	300	
	Interventional catheterization	3	250	20	550	
4	Echocardiography	1	(75/150)	3	75/150	
		2	(75/150)	6	150/300	
		3	(150/450)	12	300/750	
5	Nuclear cardiology	1	100 cases	2	100 cases	
		2	300 cases	4 to 6	300+ cases	
		3	600 cases	12	600+ cases	
6	Electrophysiology, pacing, and arrhythmias	1	20	2	10 temporary pacemakers 10 D.C. cardioversions	
		2	100	6	100 pacemaker interrogation/ reprogramming	
		3	300* prior procedure volume during Level 1 and 2 training is cumulative and counts towards overall numbers recommended for Level 3 training	12–24	150+ EP cases 75 ablations 75+ pacemaker/ICDs	*Can be taken throughout the training program.
7	Research	1		6–12‡		‡Can be taken as part of 9 months of required nonlaboratory clinical practice rotation.
		2		24		
		3		24–36		
8	Heart failure and transplantation	1		1‡§		‡Can be taken as part of 9 months of required nonlaboratory clinical practice rotation. §It is assumed that trainees will obtain additional training in heart failure and preventive cardiovascular medicine beyond the 1-month core training as part of the experience during other clinical months, such as consult services and CCU.
		2		6		
		3		12		

*Continued on next page*



**APPENDIX 1. CONTINUED**

Task Force	Area	Level	Minimal Number of Procedures	Cumulative Duration of Training (Months)	Minimal Cumulative Number of Procedures	Comments
9	Congenital heart disease	1		Core lectures‡	40 catheterizations	‡Can be taken as part of 9 months of required nonlaboratory clinical practice rotation.
		2		12	300 TTE cases	
		3		24	50 TEE cases	
10	Preventive cardiovascular medicine	1		1‡§		‡Can be taken as part of 9 months of required nonlaboratory clinical practice rotation. §It is assumed that trainees will obtain additional training in preventive cardiovascular medicine beyond the 1-month core training as part of the experience during other clinical months, such as consult services and CCU.
		2		6-12		
		3		12		
11	Vascular medicine	1		2*		*Can be taken throughout the training program.
	Vascular medicine specialist	2	475+ noninvasive vascular cases	12¶	475+ noninvasive vascular cases	The prerequisite for Level 2 training is Level 1 training in vascular medicine.
	Peripheral vascular intervention	3	100 diagnostic peripheral angiograms, 50 peripheral angioplasties/stents, 10 peripheral thrombolytic infusions/thrombectomy	12#	100 diagnostic peripheral angiograms, 50 peripheral angioplasties/stents, 10 peripheral thrombolytic infusions/thrombectomy	¶In addition to all other clinical requirements for Level 2 training. #The prerequisite for Level 3 training includes Level 1 training in vascular medicine, and Level 1 and Level 2 training in diagnostic cardiac catheterization. Requirements for Level 3 training in peripheral vascular intervention can be fulfilled during a 4th year of interventional training focused on peripheral vascular intervention or concurrently with cardiac interventional training.
12	Cardiovascular magnetic resonance	1		1**	25 cases	**Can be taken as part of 7 months of noninvasive imaging rotation.
		2		3 to 6	150 cases	
		3		12	300 cases	
13	Computed tomography	1		1**	50 cases	**Can be taken as part of 7 months of noninvasive imaging rotation.
		2		2	150 CTA cases	
		3		6	300 CTA cases	

CCU = coronary care unit; CTA = computed tomography angiography; D.C. = direct current; ECG = electrocardiogram; EP = electrophysiology; ICD = implantable cardioverter-defibrillator; TEE = transesophageal echocardiography; TTE = transthoracic echocardiography.

## APPENDIX 2. AUTHOR RELATIONSHIPS WITH INDUSTRY—ACCF 2008 RECOMMENDATIONS FOR TRAINING IN ADULT CARDIOVASCULAR MEDICINE CORE CARDIOLOGY TRAINING (COCATS 3)—TASK FORCE 1: TRAINING IN CLINICAL CARDIOLOGY

Name	Consultant	Research Grant	Scientific Advisory Board	Speakers' Bureau	Steering Committee	Stock Holder	Other
Dr. Kenneth L. Baughman	None	None	None	None	None	None	None
Dr. F. Daniel Duffy	None	None	• National Committee for Quality Assurance	None	None	None	• American Board of Internal Medicine Employee
Dr. Kim A. Eagle	None	None	None	None	None	None	None
Dr. David P. Faxon	None	None	• Johnson & Johnson	• Bristol-Myers Squibb • Sanofi	None	• Medical Technology	None
Dr. L. David Hillis	None	None	None	None	None	None	None
Dr. Richard A. Lange	None	None	None	None	None	None	None

This table represents the relationships of committee members with industry that were reported by the authors as relevant to this topic. It does not necessarily reflect relationships with industry at the time of publication.

## APPENDIX 3. PEER REVIEWER RELATIONSHIPS WITH INDUSTRY—ACCF 2008 RECOMMENDATIONS FOR TRAINING IN ADULT CARDIOVASCULAR MEDICINE CORE CARDIOLOGY TRAINING (COCATS 3)—TASK FORCE 1: TRAINING IN CLINICAL CARDIOLOGY

Name*	Affiliation	Consultant	Research Grant	Scientific Advisory Board	Speakers' Bureau	Steering Committee	Stock Holder	Other
Dr. Rick A. Nishimura	• Official—Board of Trustees	None	None	None	None	None	None	None
Dr. Chittur A. Sivaram	• Official—Board of Governors	• 3F Therapeutics	None	None	None	None	None	None
Dr. Laura F. Wexler	• Content—American Board of Internal Medicine	None	None	None	None	None	None	None

This table represents the relationships of peer reviewers with industry that were reported by the authors as relevant to this topic. It does not necessarily reflect relationships with industry at the time of publication.\*Names are listed in alphabetical order with each category of review.

## Task Force 2: Training in Electrocardiography, Ambulatory Electrocardiography, and Exercise Testing

Robert J. Myerburg, MD, FACC, *Chair*

Bernard R. Chaitman, MD, FACC, Gordon A. Ewy, MD, FACC, Michael S. Lauer, MD, FACC

### Electrocardiography

#### Importance

Electrocardiography is the most commonly used diagnostic test in cardiology. Properly interpreted, it contributes significantly to the diagnosis and management of patients with cardiac disorders. Importantly, it is essential to the diagnosis

of cardiac arrhythmias and the acute myocardial ischemic syndromes. These 2 conditions account for the majority of cardiac catastrophes. It is appropriately used as a screening test in many circumstances.

#### Goal of Training

Although every physician should have a basic knowledge of electrocardiography, and the general internist should have

more advanced knowledge than most others, the subspecialist in cardiology should be familiar with nearly all clinically encountered patterns of depolarization and repolarization and of arrhythmias. The trainee should understand clinical implications, sensitivity, and specificity of the test, and should be able to identify normal variants. The trainee should have sufficient basic knowledge to understand the physiologic mechanisms for arrhythmias and electrocardiographic waveforms rather than to simply recognize patterns. The recognition and understanding of the basis for the items included in Appendix 1 of this task force report are minimum requirements for each trainee.

The trainee should also be familiar with the instrumentation necessary to acquire, process, and store electrocardiograms (ECGs), in both analog and digital format. The trainee should understand the effect of acquisition rates and filter settings, as well as recognize electronic artifacts. The trainee should be able to accurately measure basic ECG intervals in both analog and digital systems.

### Training

An essential feature of training is to interpret a large number of ECGs and to review all interpretations with experienced faculty. The committee recommends that all trainees achieve Level 2 training in ECG interpretation. This necessitates interpreting 3500 ECGs over 24 to 36 months (Table 1). These should be documented individually. This may be accomplished by 1 or more training periods assigned specifically for interpretation of ECGs, or it may be an experience provided in a continuing manner. The experience should include clinical correlation in patients in intensive care units, emergency rooms, and pacemaker/defibrillation clinics. The ECG should be integrated with the clinical problem. Formal courses and correlative conferences in electrocardiography are strongly recommended. In addition, guidelines for the role of electrocardiography in clinical practice should be thoroughly understood, reviewed, and followed (1).

### In-Training Evaluation

The trainee must become familiar with the indications for electrocardiography and electrophysiologic studies. Similarly, the trainee should be familiar with the principles of intracardiac electrophysiologic studies, their indications, contraindications, sensitivity, and specificity (see the Task Force 6 report). The trainee should be evaluated on an ongoing basis by responsible faculty to determine that the trainee has integrated these knowledge bases. Because of variability in training in electrocardiography and to document the trainee's proficiency, an in-training examination in electrocardiography should be used and implemented by each training program. The Adult Clinical Cardiology Self-Assessment Program (ACCSAP) contains a self-assessment examination in electrocardiography, which is available on a national basis and is useful for identifying knowledge areas of specific weakness and levels of proficiency.

### Ambulatory ECG Monitoring

#### Importance

Observation and documentation of cardiac rhythm during daily activities, as well as the relation of the rhythm disturbances to patient symptoms, are important factors for clinical decision making. Major indications for ambulatory ECG monitoring include the following: detection of or ruling out of rhythm disturbances as a cause of symptoms; detection and assessment of arrhythmias believed to be associated with an increased risk for cardiovascular events; the identification and accurate interpretation of ambulatory ST-T wave changes occurring throughout a diurnal time period; assessment of efficacy of antiarrhythmic and anti-ischemic therapy; and investigation of the effects of therapeutic devices (e.g., pacemakers and implantable cardioverter-defibrillator).

**Table 1 Summary of Training Requirements in Electrocardiography, Ambulatory Electrocardiography, and Exercise Testing**

Task Force	Area	Level	Minimal Number of Procedures	Cumulative Duration of Training (Months)	Minimal Cumulative Number of Cases	Comments
2	Electrocardiography	1	3500*†		3500	*Can be taken throughout the training program. †The committee strongly recommends that cardiologists achieve Level 2 training in ECG interpretation.
		2	3500	36		
	Ambulatory monitoring	1	150*		150	*Can be taken throughout the training program.
		2	75		225	
	Exercise testing	1	200*		200	*Can be taken throughout the training program.
		2	100		300	

ECG = electrocardiogram.

## Goal of Training

The technology is not perfect, and multiple methods of recording and analysis are currently in use. The trainee should understand the differences between continuous and intermittent recordings and the advantages and disadvantages of each and should have a basic knowledge of the various methods used for arrhythmia and ST-segment detection, classification, and analysis. The trainee should understand the potential pitfalls inherent in each method. In addition, the trainee should have current knowledge about what may represent a “normal” finding for various age groups during sleeping and waking hours and what should be considered “abnormal,” realizing that the clinical significance of some findings on ambulatory monitoring is still unresolved.

## Structure of Training

The trainee should participate in interpretation sessions with a staff cardiologist knowledgeable in the indications for the test, the techniques of recording, and the clinical significance and correlations of findings. It is recommended that the trainee interpret a minimum of 150 ambulatory ECG recordings over 24 to 36 months. Ideally, the trainee should be exposed to both full-disclosure (complete print-out) and computer-assisted systems so that the advantages, disadvantages, and cost of each may be understood. In addition, transtelephonic and event-recorder devices are increasingly used on an adjunct basis for prolonged ambulatory electrocardiography. Knowledge of their indications and limitations must also be gained, preferably from structured training in ambulatory electrocardiography that permits interaction of the trainee with an experienced cardiovascular technician and ambulatory ECG instrumentation and review of interpreted records with the attending cardiologist with specific expertise in ambulatory electrocardiography. Such training will provide knowledge to satisfy clinical competence in ambulatory electrocardiography as indicated by the American College of Cardiology (ACC)/American Heart Association (AHA)/American College of Physicians–American Society of Internal Medicine (ACP–ASIN) Task Force on Clinical Competence (1).

Level 2 trainees will interpret a minimum of 75 additional recordings over 12 months (a total of 225 recordings over 36 months). Such recordings or other provided material should include all forms of artifact, pacemaker, and implantable cardioverter-defibrillator patterns, heart rate variability studies, repolarization abnormalities (e.g., QT or T wave alternans), and applications of the signal-averaged ECG. Such trainees will demonstrate knowledge of the operation and limitations of a variety of types of ambulatory ECG instrumentation. Additional ECG interpretation of in-hospital telemetry ECGs is required. This may range from 6 to 8 s of real-time printout strips to 72 h of full-disclosure data. Such ECG data often augment standard and ambulatory electrocardiography. Trainees will be experienced in

the interpretation and limitations, since knowledge at this level also supports the objectives of Level 2 training in electrophysiology, pacing, and arrhythmia management (see the Task Force 6 report).

## In-Training Evaluation

Because of the large number of different rhythm patterns seen during routine clinical ambulatory ECG recordings and the many technologic approaches, it may not be possible to assess adequately a trainee’s expertise in ambulatory electrocardiography by a uniform, written examination. Thus, the trainee must be given the responsibility for initial interpretation of all phases of the ambulatory ECG study. The trainee should provide a detailed interpretation and review it with the attending cardiologist responsible and experienced in ambulatory electrocardiography. This attending cardiologist is responsible for the evaluation and documentation of a trainee’s progress and skills.

## Evolving New Applications

Long-term ambulatory electrocardiography continues to evolve with regard to QT measurements and heart rate variability studies. These measurements provide insight into ventricular repolarization changes and the autonomic nervous system (sympathetic and parasympathetic) over extended periods of ambulatory electrocardiography. Trainees should be cognizant of these developments and follow their evolution and clinical application.

## Exercise Testing

### Importance

Exercise testing is an important physiologic procedure used to elicit cardiovascular abnormalities not present at rest and to determine adequacy of cardiac function. These tests are valuable clinical procedures used to assess patients with suspected or proven cardiovascular disease. Exercise testing is used primarily to estimate prognosis, determine functional capacity, provide a diagnostic estimate of the likelihood and extent of coronary disease, and determine the effects of therapy. Exercise electrocardiography is also combined with ancillary techniques such as radionuclide imaging, echocardiography, or metabolic gas analysis to enhance the information content of the test in selected patients.

### Goal of Training

The trainee should become proficient at performing both heart rate-limited and maximal or near-maximal treadmill exercise tests and should have the opportunity to learn alternative exercise testing techniques. The training program should provide the opportunity for the trainee to become knowledgeable in exercise physiology and pathophysiology. The trainee should also be taught the essentials of exercise testing, such as skin preparation, electrode selection and application, choice of exercise testing proto-



cols, blood pressure monitoring during exercise, and monitoring of the patient for adverse signs or symptoms. The trainee should be thoroughly familiar with evidence-based indications and contraindications to exercise testing. The trainee must become proficient in the interpretation of commonly used measurements available from the exercise test. These include the onset and offset of ischemic ST-segment depression and the distinction between normal variants and abnormal patterns, exercise-induced cardiac arrhythmias, magnitude and slope of ST-segment depression or elevation, ST/heart rate indexes, exertional hypotension, chronotropic incompetence, heart rate recovery, and hemodynamic measurements such as maximum exercise heart rate, systolic blood pressure, and double product. The trainee should become proficient in integrating the data, understanding the reasons for stopping exercise, and establishing diagnostic accuracy (sensitivity and specificity) and prognostic importance of the procedure in different clinical settings as described in the ACC/AHA guidelines for exercise testing (2). This training will provide knowledge to satisfy clinical competence in exercise testing, as indicated by the ACC/AHA/ACP-ASIN Task Force on Clinical Competence.

### Structure of Training and In-Training Evaluation

The training of a fellow in cardiology should include at least 2 months, or the equivalent, of active participation in a fully equipped exercise testing laboratory, during which time the fellow should perform a minimum of 200 exercise tests reviewed by faculty. This experience can be obtained concurrently with training in an exercise imaging laboratory as part of the training requirements in nuclear cardiology or echocardiography. Level 1 trainees will gain proficiency in the standard exercise test and its interpretation (minimum experience 200 tests), to include pharmacologic testing (dipyridamole, adenosine, and dobutamine), whereas Level 2 trainees (additional 100 tests) will become experienced in advanced forms of exercise testing, which include arrhythmia evaluation, ventilatory gas studies, pulmonary function testing as part of cardiopulmonary stress testing, stress echocardiographic techniques, and nuclear cardiology (see the Task Force 4 and 5 reports).

The laboratory should be engaged in the performance of exercise tests on a regular basis that involve a broad spectrum of both inpatients and outpatients with a variety of known and suspected cardiac disorders. The training program should be structured so that the trainee is guided in the laboratory by a specially trained exercise professional until the trainee has become proficient at conducting and monitoring exercise tests under a variety of clinical circumstances. The trainee must be given the responsibility for initial interpretation of all phases of the exercise study, providing a detailed interpretation, and reviewing it with the attending cardiologist responsible and experienced in exercise testing. The faculty physician should assess and

document the trainee's progress on a regular basis, including technical performance and ability to interpret results.

*This is a revision of the 2002 document that was written by Robert J. Myerburg, MD, FACC—Chair; Bernard R. Chaitman, MD, FACC; Gordon A. Ewy, MD, FACC; and Melvin M. Scheinman, MD, FACC.*

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### TASK FORCE 2 REFERENCES

1. Kadish AH, Buxton AE, Kennedy HL, et al. ACC/AHA clinical competence statement on electrocardiography and ambulatory electrocardiography: a report of the ACC/AHA/ACP-ASIM Task Force on Clinical Competence (ACC/AHA Committee to Develop a Clinical Competence Statement on Electrocardiography and Ambulatory Electrocardiography). *J Am Coll Cardiol* 2001;38:2091-100.
2. Rodgers GP, Ayanian JZ, Balady G, et al. American College of Cardiology/American Heart Association Clinical Competence statement on stress testing: a report of the American College of Cardiology/American Heart Association/American College of Physicians—American Society of Internal Medicine Task Force on Clinical Competence. *J Am Coll Cardiol* 2000;36:1441-53.

**Key Words:** ACCF Training Statement ■ COCATS 3 ■ electrocardiogram ■ electrocardiography ■ ambulatory electrocardiography ■ exercise testing.

### APPENDIX 1: ELECTROCARDIOGRAPHIC KNOWLEDGE BASE AND INTERPRETATION

#### Anatomy and Electrophysiology

1. Anatomy of the specialized conducting system (sinoatrial node, atrioventricular node, His bundle, bundle branches), concept of the trifascicular conduction system
2. Spread of excitation in the ventricles
3. Difference between unipolar and bipolar leads
4. Einthoven triangle; frontal and horizontal lead reference system
5. Vectorial concepts
6. Significance of a positive and negative deflection in relation to lead axis
7. Relation between electrical and mechanical activity

#### Technique and the Normal ECG

8. Effect of improper electrode placement (limb and precordial)
9. Effect of muscle tremor
10. Effect of poor frequency response of the equipment
11. Effect of uneven paper transport
12. Measurement of PR, QRS, QT, normal values/rate correction of QT interval
13. Normal ranges of axis in the frontal plane
14. Effect of age, weight, and body build on the axis in the frontal plane, as well as specific ECG diagnoses (i.e., left ventricular hypertrophy, left ventricular hypertrophy, and strain)
15. Normal QRS/T angle

16. Differential diagnosis of normal ST-T, T-wave variants (e.g., "juvenile" pattern and early repolarization syndrome)

### Arrhythmias: General Concepts

17. Reentry, automaticity, triggered activity
18. Aberration (various mechanisms)
19. Capture and fusion complexes
20. Escape (passive, accelerated) complexes or rhythms: atrial, junctional, and ventricular
21. Interpolated premature beat
22. Parasystole (atrial, junctional, ventricular), modulated parasystole
23. Vulnerability
24. Exit block
25. Reciprocation
26. Concealed conduction
27. Supernormality

### Arrhythmias: Recognition

#### *Sinoatrial Rhythm*

28. Sinus tachycardia
29. Sinus bradycardia
30. Sinus arrhythmia
31. Sinoatrial arrest
32. Sinoatrial block

#### *Atrial Rhythms*

33. Atrial premature complexes (conducted, nonconducted)
34. Atrial tachycardia (ectopic)
35. Atrial tachycardia with atrioventricular block
36. Atrial fibrillation
37. Atrial flutter (typical and atypical forms)
38. Multifocal atrial tachycardia
39. Wandering atrial pacemaker-multifocal atrial rhythm

#### *Atrioventricular Node (Junctional)*

40. Premature junctional complexes
41. Atrioventricular node re-entrant tachycardia (common and uncommon type)
42. Nonparoxysmal junctional tachycardia-accelerated junctional rhythm
43. Atrioventricular re-entrant or circus movement tachycardia with an accessory pathway
44. Escape complex or escape rhythm

#### *Ventricular*

45. Ventricular ectopic complexes
46. Accelerated idioventricular rhythm
47. Ventricular tachycardia: uniform (monomorphic), multiform (pleomorphic or polymorphic), sustained, nonsustained, bidirectional, and torsades de pointes
48. Ventricular flutter, ventricular fibrillation
49. Ventriculoatrial conduction

50. Ventricular escape or idioventricular rhythm

#### *Atrioventricular Dissociation Due To:*

51. Slowing of dominant pacemaker
52. Acceleration of subsidiary pacemaker
53. Above with depression of atrioventricular conduction
54. Third-degree atrioventricular block
55. Isorhythmic atrioventricular dissociation

#### *Atrioventricular Block*

56. First degree
57. Second degree; 2:1, Mobitz type I (Wenckebach), Mobitz type II, high-degree atrioventricular block
58. Third-degree atrioventricular block (complete)
59. Significance of wide versus normal QRS complex

#### *Waveform Abnormality*

#### *Abnormalities of Repolarization (Concept of Primary and Secondary ST-T Wave Change); Abnormalities of U Wave; Ventricular Hypertrophy*

60. Left ventricular hypertrophy: criteria for left ventricular hypertrophy; specificity and sensitivity of criteria
61. Right ventricular hypertrophy: criteria for right ventricular hypertrophy; sensitivity and specificity of the criteria
62. Biventricular hypertrophy
63. Electrical alternans

#### *Atrial Abnormalities*

64. Criteria for left atrial abnormality
65. Criteria for right atrial abnormality
66. Biatrial abnormality
67. Clinical significance of atrial abnormalities

#### *Intraventricular Conduction Disturbances*

68. Anatomic and electrophysiologic basis for intraventricular conduction defects
69. Criteria for incomplete and complete left bundle-branch block
70. Criteria for the diagnosis of incomplete and complete right bundle-branch block
71. Criteria for left anterior and posterior fascicular blocks
72. Concept of combined bundle and fascicular blocks
73. Indeterminate intraventricular conduction defects
74. Diagnosis and classification of pre-excitation syndromes (e.g., Wolff-Parkinson-White syndrome)

#### *Myocardial Ischemia and Infarction*

75. Transient ischemia and injury
76. Normal Q waves
77. Abnormal Q waves not associated with infarction
78. Differential diagnosis of tall R wave in right precordial leads
79. Theoretical basis of ECG changes in acute myocardial infarction (Q, ST-T waves)

80. Time course of ST-segment changes in acute myocardial infarction
81. Diagnosis of myocardial infarction (without Q waves)
82. ST-segment changes in conditions other than myocardial infarction
83. Localization of myocardial infarction
84. QRS residuals of old myocardial infarction
85. Reliability of QRS and ST-segment changes of myocardial infarction in previously abnormal ECG: intraventricular conduction defects; ventricular hypertrophy
86. Overall assessment of serial ECGs as to the probability of acute myocardial infarction

#### **Pacemaker**

87. Fixed-rate pacemaker
88. Atrial pacing
89. Ventricular demand pacing
90. Atrial triggered ventricular pacing
91. Atrioventricular dual pacing
92. Malfunctioning: demand acting as fixed rate; failure to sense; slowing of rate; acceleration of rate; failure to capture; failure to pace (inappropriate inhibition)

#### **Exercise ECG Test**

93. Criteria for a positive response
94. Significance of an abnormal baseline ECG; effect of drugs; effect of pre-excitation
95. Significance of heart rate and blood pressure response (normal and abnormal)
96. Sensitivity: false-negative (incidence and principal causes)
97. Specificity: false-positive (incidence and principal causes)
98. Significance of magnitude of ST-segment changes
99. Normal responses to maximum exercise testing
100. Exercise-induced rapid versus slow upsloping ST-segment depression
101. Exercise-induced minor versus abnormal horizontal or downsloping ST-segment depression
102. Exercise-induced ST-segment elevation in noninfarct-related versus infarct-related leads
103. Exercise-induced intraventricular conduction disturbance
104. Exercise-induced ventricular and supraventricular arrhythmias
105. Exercise-induced hypertensive or hypotensive response

106. Sensitivity, specificity, and predictive accuracy in clinical patient subsets
107. Identification of chronotropic incompetence or accelerated ventricular response
108. Utility of peak exercise capacity, ECG, hemodynamic response, and exercise-induced symptoms
109. Noncoronary causes of exercise-induced ST-segment depression
110. Exercise parameters that indicate adverse prognosis or multivessel coronary disease
111. Indications and contraindications for exercise testing
112. Exercise testing with ventilatory gas analysis
113. Exercise testing in special groups: women, asymptomatic subjects, post-revascularization patients, post-myocardial infarction or acute coronary syndrome patients
114. Evaluation of valvular heart disease
115. Evaluation of cardiac arrhythmias
116. Interpretation of exercise test results in subjects with resting ST-segment depression, left ventricular hypertrophy, Wolff-Parkinson-White syndrome, pacemakers, or cardiomyopathy

#### **Clinical Diagnoses (Selected)**

117. Hyperkalemia
118. Hypokalemia
119. Hypercalcemia
120. Hypocalcemia
121. Long-QT syndromes (congenital and acquired)
122. Atrial septal defect, secundum
123. Atrial septal defect, primum
124. Dextrocardia
125. Mitral stenosis
126. Chronic obstructive pulmonary disease
127. Acute cor pulmonale
128. Pericardial effusion
129. Acute pericarditis
130. Hypertrophic cardiomyopathy
131. Central nervous system disorder
132. Myxedema
133. Hypothermia
134. Sick sinus syndrome
135. Digitalis effect or toxicity
136. Effects of other drugs (e.g., tricyclic or antiarrhythmic agents)
137. Possible proarrhythmic effects

**APPENDIX 2. AUTHOR RELATIONSHIPS WITH INDUSTRY—ACCF 2008 RECOMMENDATIONS FOR TRAINING IN ADULT CARDIOVASCULAR MEDICINE CORE CARDIOLOGY TRAINING (COCATS 3)—TASK FORCE 2: TRAINING IN ELECTROCARDIOGRAPHY, AMBULATORY ELECTROCARDIOGRAPHY, AND EXERCISE TESTING**

Name	Consultant	Research Grant	Scientific Advisory Board	Speakers' Bureau	Steering Committee	Stock Holder	Other
Dr. Bernard R. Chaitman	<ul style="list-style-type: none"> <li>• CV Therapeutics</li> <li>• Merck</li> </ul>	<ul style="list-style-type: none"> <li>• Berlex</li> <li>• CV Therapeutics</li> <li>• Pfizer</li> </ul>	<ul style="list-style-type: none"> <li>• CV Therapeutics</li> <li>• GE Healthcare</li> </ul>	<ul style="list-style-type: none"> <li>• Pfizer</li> </ul>	None	None	None
Dr. Gordon A. Ewy	None	None	None	<ul style="list-style-type: none"> <li>• AstraZeneca</li> <li>• Kos Pharmaceuticals</li> <li>• Merck</li> <li>• Pfizer</li> <li>• Schering-Plough Pharmaceuticals</li> <li>• Wyeth Pharmaceuticals</li> </ul>	None	None	None
Dr. Michael S. Lauer	None	None	None	None	None	None	None
Dr. Robert J. Myerburg	<ul style="list-style-type: none"> <li>• Procter &amp; Gamble</li> <li>• Reliant Pharmaceuticals</li> </ul>	None	None	<ul style="list-style-type: none"> <li>• Guidant</li> <li>• Procter &amp; Gamble</li> <li>• Reliant Pharmaceuticals</li> </ul>	None	None	<ul style="list-style-type: none"> <li>• Guidant (Independent Panel on Device Malfunction)</li> </ul>

This table represents the relationships of committee members with industry that were reported by the authors as relevant to this topic. It does not necessarily reflect relationships with industry at the time of publication.

**APPENDIX 3. PEER REVIEWER RELATIONSHIPS WITH INDUSTRY—ACCF 2008 RECOMMENDATIONS FOR TRAINING IN ADULT CARDIOVASCULAR MEDICINE CORE CARDIOLOGY TRAINING (COCATS 3)—TASK FORCE 2: TRAINING IN ELECTROCARDIOGRAPHY, AMBULATORY ELECTROCARDIOGRAPHY, AND EXERCISE TESTING**

Name	Affiliation	Consultant	Research Grant	Scientific Advisory Board	Speakers' Bureau	Steering Committee	Stock Holder	Other
Dr. Gordon L. Fung	<ul style="list-style-type: none"> <li>• Official—Board of Governors</li> </ul>	None	None	None	<ul style="list-style-type: none"> <li>• AstraZeneca</li> <li>• CV Therapeutics</li> <li>• GlaxoSmithKline</li> <li>• Merck</li> <li>• Novartis</li> <li>• Pfizer</li> </ul>	None	None	None
Dr. Richard J. Kovacs	<ul style="list-style-type: none"> <li>• Official—Board of Governors</li> </ul>	<ul style="list-style-type: none"> <li>• Biosignals</li> <li>• Eli Lilly</li> <li>• Oxford</li> <li>• Xenoplast</li> </ul>	None	None	<ul style="list-style-type: none"> <li>• CV Therapeutics</li> </ul>	None	None	None
Dr. Rick A. Nishimura	<ul style="list-style-type: none"> <li>• Official—Board of Trustees</li> </ul>	None	None	None	None	None	None	None

This table represents the relationships of peer reviewers with industry that were reported by the authors as relevant to this topic. It does not necessarily reflect relationships with industry at the time of publication.



## Task Force 3: Training in Diagnostic and Interventional Cardiac Catheterization

*Endorsed by the Society for Cardiovascular Angiography and Interventions*

Alice K. Jacobs, MD, FACC, *Chair*

Joseph D. Babb, MD, FACC (*Society for Cardiovascular Angiography and Interventions Representative*),

John W. Hirshfeld, JR, MD, FACC, David R. Holmes, JR, MD, FACC

### Background

Since the second edition of Task Force 3 of the American College of Cardiology (ACC) Core Cardiology Training Symposium (COCATS) guidelines was published (1), both the cognitive knowledge and technical skill required of the invasive and interventional cardiologist have continued to grow. Concomitantly, the role of the cardiac catheterization laboratory in trainee education and as a clinical care facility continues to evolve. The cardiac catheterization laboratory serves as both a diagnostic and therapeutic facility. It has an important diagnostic role in the evaluation and management of all types of heart disease: coronary, valvular, congenital, and primary myocardial. This role includes invasive hemodynamic measurements and angiographic delineation of cardiovascular anatomy and pathology. The information derived from these studies has a complementary overlap with that derived from other diagnostic modalities such as echocardiography, computed tomography (CT), and magnetic resonance imaging (MRI). This relationship has value both in enhancing diagnostic accuracy and in fostering the understanding of cardiovascular physiology, pathology, and pathophysiology. The widespread use of echocardiography in addition to the growing use of cardiovascular magnetic resonance (CMR) and CT angiography has also changed the practice of invasive and interventional cardiology. Patients with diagnostic echocardiographic hemodynamic assessment of valvular or myocardial/pericardial disease may be referred for diagnostic coronary angiography only. However, patients in whom the echocardiographic findings are conflicting are still referred to the catheterization laboratory for hemodynamic assessment; these patients are often exceedingly complex. Thus, somewhat paradoxically in this era of enhanced noninvasive imaging, the understanding and proper performance of detailed hemodynamic evaluation in such patients is of even greater importance.

The therapeutic role of the cardiac catheterization laboratory continues to increase as interventional cardiology procedures are applied to increasingly complex and critically ill patients.

Urgent catheterization and percutaneous revascularization are now considered to be the standard of care for patients with unstable coronary ischemic syndromes, ST-elevation myocardial infarction, and cardiogenic shock. Furthermore, new adjunctive pharmacologic regimens and interventional devices have emerged. In addition, many noncoronary therapeutic procedures including percutaneous closure of atrial septal defects and patent foramen ovale, valve repair or replacement, and septal artery ablation are currently in various stages of investigation and are likely to significantly expand the scope of the field of interventional cardiology. This evolution has increased the cognitive and technical knowledge base required of invasive and interventional cardiologists. Consequently, this document revises and updates the standards for training in invasive cardiology.

The American Board of Internal Medicine (ABIM) provides an added qualification certifying examination in interventional cardiology, and the Residency Review Committee of the American Council for Graduate Medical Education (ACGME) has a formal accreditation mechanism for interventional cardiology training programs. The recommendations in this document are consistent with the requirements of the ABIM and the ACGME. In 1999, the ACC published a training statement on recommendations for the structure of an optimal adult interventional cardiology training program (2), and the recommendations are summarized in this document.

### Program Accreditation

Training in diagnostic cardiac catheterization (Levels 1 and 2) must occur within a cardiology training program that is fully accredited by the ACGME. If the program does not include an accredited training program in interventional cardiology, exposure to an active interventional cardiology program should be provided. Training in interventional cardiology (Level 3) must occur within an ACGME-accredited program. All interventional cardiology training programs in the United States must satisfy the basic standards developed by the ACGME

and must be accredited by the ACGME for candidates to be eligible for the clinical interventional cardiology certificate of added qualification of the ABIM. The ACGME standards represent the qualifying requirements. This document endorses the ACGME standards for program accreditation and makes additional recommendations over and above those standards.

## Program Goals

The ultimate goal of a cardiac catheterization training program is to teach the requisite cognitive and technical knowledge of invasive cardiology. This includes indications and contraindications for the procedures, pre- and post-procedure care, management of complications, and analysis and interpretation of the hemodynamic and angiographic data. The cardiac catheterization laboratory provides a platform for the teaching of the core knowledge bases of cardiac anatomy, pathology, physiology, and pathophysiology that should be possessed by all cardiologists whether or not they perform invasive cardiovascular procedures. In addition, it is the facility that provides training in the basic intravascular catheter insertion and manipulation skills needed to care for cardiac patients in critical care environments. The trainee's overall professional goals determine the requisite knowledge and skill set to be acquired. In general, trainees may be divided into 3 broad groups with differing training requirements:

**Level 1**—Trainees who will practice noninvasive cardiology and whose invasive activities will be confined to critical care unit procedures. However, this level will provide training in the indications for the procedure and in the accurate interpretation of data obtained in the catheterization laboratory.

**Level 2**—Trainees who will practice diagnostic but not interventional cardiac catheterization.

**Level 3**—Trainees who will practice diagnostic and interventional cardiac catheterization.

Each level has specific goals for training that build on each other and which are detailed in the following text. All cardiologists should have Level 1 knowledge and skills.

## Program Structure

### Faculty

Faculty should be full-time, experienced, and committed to the teaching program. Exposure to multiple faculty mentors substantially enhances the quality of a training experience. The faculty should consist of a program director, key faculty, and other associated faculty. An optimal program should have a minimum of 3 key faculty members, one of whom is the program director and each of whom maintains a minimum procedural volume of 150 diagnostic catheter-

ization procedures per year and devotes at least 20 h per week to the program. Associated faculty may have varying levels of commitment and involvement in the program.

### Program Director

The program director for the invasive cardiology curriculum should be certified in cardiovascular medicine by the ABIM and should be recognized as an expert in cardiac catheterization. Preferably, the program director will have completed his or her training at least 5 years previously and will be a full-time faculty member of the overall cardiovascular training program and committed to medical education and teaching. If the program also provides training in interventional cardiology, the program director must be board-certified in interventional cardiology and should have a career experience of at least 5 years after completion of training, including an aggregate experience of 1000 coronary interventional procedures. The program director should be responsible for the invasive teaching curriculum and overall teaching program in addition to trainee evaluation. If the program director is the director of the catheterization laboratory, this individual should also be responsible for the administration of the laboratory, quality assurance, and radiation safety.

### Other Key Faculty

Key faculty members should be certified in cardiovascular medicine by the ABIM and have expertise in all aspects of diagnostic procedures, including the evaluation of coronary, valvular, congenital, and cardiomyopathic disease, and should be familiar with complex hemodynamics in patients with all types of heart disease. The program faculty should include individuals with expertise in the performance of myocardial biopsies, trans-septal catheterization, and the interpretation and performance of intracoronary ultrasound and intracoronary physiologic assessment (Doppler coronary flow and intracoronary pressure measurement), although each member need not have expertise in every area. If the program also provides training in interventional cardiology, its faculty must satisfy the requirements for accreditation in interventional cardiology by the ACGME ([http://www.acgme.org/acWebsite/RRC\\_140/140\\_prIndex.asp](http://www.acgme.org/acWebsite/RRC_140/140_prIndex.asp)) and the requirements outlined in the previously published ACC training statement (2). Ideally, in institutions where patient volume is adequate, the program should include faculty who possess skills in advanced interventional cardiovascular techniques such as patent foramen ovale and atrial septal defect closure, septal ablation for hypertrophic obstructive cardiomyopathy, and balloon valvuloplasty. In addition, ideally the program should include faculty with expertise in peripheral vascular disease.

### Facilities and Environment

All training facilities must be equipped and staffed to function in accordance with the ACC/Society for Cardiovascular Angiography and Interventions clinical expert con-

sensus document on cardiac catheterization laboratory standards (3).

### X-Ray Imaging Equipment

The cardiac catheterization laboratory must generate high quality X-ray digital images during diagnostic and interventional catheterization procedures. The laboratory must have access to the support personnel needed to ensure that image quality is optimal and that radiation exposure to patients and staff is minimized.

### Hemodynamic Monitoring and Recording Equipment

The facility must have high-quality physiologic monitoring and recording equipment to permit the accurate assessment of complex hemodynamic conditions. The presence of equipment for assessment of coronary physiology such as fractional flow reserve, Doppler coronary velocity, and coronary anatomy such as intravascular ultrasound and intracardiac echocardiography (the latter for programs performing percutaneous treatment of structural heart disease), is strongly recommended.

### Ancillary Support Capabilities

The program must have on-site access to all core cardiology services, including a cardiac critical care facility, echocardiography, stress testing with nuclear imaging, and electrophysiologic testing. Required on-site support services for interventional cardiology training include cardiac surgery, anesthesia, vascular and interventional radiology, vascular surgery, nephrology, and hematology.

### Program Activity Level and Patient Mix

Level 1 and Level 2 training require comprehensive exposure to the full variety of cardiovascular disorders and clinical procedures. This is important not only to provide direct hands-on training experience but also to provide the requisite material for clinical conferences. In addition to experience with the many manifestations of coronary artery disease, all trainees should also acquire experience in the hemodynamic assessment, evaluation, and management of patients with valvular, myocardial, and congenital heart disease. Level 3 training requires exposure to the full spectrum of cardiac ischemic syndromes and noncoronary heart disease (2) to provide comprehensive experience in the scope of interventional cardiology procedures and to maintain faculty expertise.

### Duration of Training

#### Level 1 (Minimum of 4 Months)

Level 1 training requires a minimum of 4 months of experience in the cardiac catheterization laboratory. During this period, a trainee should participate in a minimum of 100 diagnostic cardiac catheterization procedures over a period of 2 to 3 years (Table 1). Only one Level 1 trainee may claim credit for participation in a given procedure. An essential part of this training is the instruction in evaluating hemodynamic data and reading cardiac and coronary angiographic studies, and the trainee should acquire Level 1 cognitive knowledge (see Training Program Curriculum).

#### Level 2 (Minimum of 8 Months Over a 3-Year Period)

Level 2 training requires a minimum of 8 months (over the course of 3 years) in the cardiac catheterization laboratory and participation in the performance (under direct supervision) of a minimum of 300 diagnostic cardiac catheterization procedures (Table 1). Only one Level 2 trainee may claim credit for participation in a given procedure. During this period, the trainee should acquire Level 2 cognitive knowledge (see Training Program Curriculum).

#### Level 3

Level 3 training must be performed during a fourth year of fellowship dedicated primarily to cardiovascular interventional training (2). During this period, the trainee should participate in a minimum of 250 coronary procedures (Table 1) (with each patient counting as 1 procedure regardless of the number of interventions) in addition to other noncoronary interventional procedures and acquire Level 3 cognitive knowledge (2).

### Conduct of Training

The nature of a trainee's participation in a given procedure will vary depending on the procedure's complexity and the trainee's experience level. Requisite participation in a procedure includes the following elements:

1. *Pre-procedural evaluation to assess appropriateness and to plan procedure strategy.* Before the procedure, it is expected that the trainee will review the patient's medical record and obtain a confirmatory history and physical examination, with specific attention given to factors known to increase the risk of the procedure, such as vascular disease, renal failure, history of contrast reaction, congestive heart failure, anemia, active infection,

**Table 1** Summary of Training Requirements in Diagnostic and Interventional Cardiac Catheterization

Task Force	Area	Level	Minimal Number of Procedures	Cumulative Duration of Training (Months)	Minimal Cumulative Number of Cases
3	Diagnostic catheterization	1	100	4	100
		2	200	8	300
	Interventional catheterization	3	250	20	550

and conditions known to increase the risk of bleeding. The trainee should also obtain informed consent and document a pre-procedural note that includes indications for the procedure, risks of the procedure, and alternatives to the procedure.

2. *Performance of the procedure by the trainee at a level appropriate to experience, always (at all levels) under the direct supervision of a program faculty member.* Level 1 trainees will begin in a mostly observational role and assume greater participation as experience is gained. Level 2 trainees will assume progressive responsibility for the conduct of diagnostic procedures as they acquire skills. Highly experienced Level 2 (or Level 3) trainees may collaborate in a procedure with Level 1 trainees under the direct supervision of a program faculty member. In this circumstance, both Level 1 and Level 2 (or Level 3) trainees may claim credit for participation in the procedure. Level 3 trainees will assume progressive responsibility for the performance of interventional procedures as they acquire skills.
3. *Participation in the analysis of the hemodynamic and angiographic data obtained during the procedure and preparation of the procedure report.*
4. *Active involvement in post-procedural management both in and out of the catheterization laboratory.* After the procedure, a preliminary catheterization report or note should be placed in the patient's file. The trainee should monitor the patient's status and be available to respond to any adverse reactions or complications that may arise, such as hypotension, vascular complications, heart failure, renal failure, bleeding, or myocardial ischemia. A post-procedural note should be completed before hospital discharge. If a complication occurs, the trainee should participate in the follow-up and management of the complication.

## Training Program Curriculum

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The trainee should possess the cognitive knowledge and technical skills detailed in the following text.

### Knowledge Base

#### Level 1 Cognitive Knowledge

1. Understand coronary anatomy, its variations, and congenital abnormalities
2. Understand coronary physiology
3. Understand cardiac hemodynamics, including the measurement and interpretation of pressure, flow, resistance, and cardiac output. Understand ventricular and myocardial mechanics and the determinants of cardiovascular performance
4. Interpret hemodynamic findings in a variety of cardiac conditions, including various forms of myocardial disease, pericardial disease, valvular stenosis and regurgi-

tation, congenital heart disease, and pulmonary vascular disease. Understand how to differentiate the hemodynamics of constrictive pericarditis from restrictive cardiomyopathy

5. Understand the relationship between hemodynamic assessment as determined by invasive measurements and echocardiography in addition to other noninvasive modalities
6. Understand the indications and contraindications for cardiac catheterization and coronary intervention
7. Understand the complications of the procedure and their management, such as hypotension, acute myocardial ischemia, congestive heart failure, renal failure, contrast reactions, retroperitoneal bleeding, cardiac tamponade, vascular problems, arrhythmias, and stroke
8. Select the optimal treatment modality, including medical therapy, percutaneous coronary and noncoronary intervention, or surgical therapy, with understanding of the indications for and risks of each revascularization strategy
9. Understand the indications for and complications of temporary transvenous pacing
10. Understand the indications for and complications of pericardiocentesis and recognize tamponade physiology
11. Understand the indications for and complications of other laboratory procedures, such as endomyocardial biopsy, intra-aortic balloon counterpulsation, and retrieval of foreign bodies
12. Understand basic principles of X-ray imaging, radiation protection, and radiation safety
13. Understand the anatomy of and methods to access cardiac chambers and coronary arteries via the femoral, brachial, and radial access sites
14. Interpret diagnostic coronary angiograms and appreciate the interface with noninvasive techniques of coronary imaging
15. Interpret ventricular, atrial, and aortic angiography and determine left ventricular ejection fraction
16. Understand the indications for and complications of contrast agents, the risk of contrast nephropathy, and the risks and benefits of various renal protective regimens
17. Understand the indications for and complications of drugs commonly used for invasive procedures, such as unfractionated heparin, low-molecular-weight heparin, glycoprotein IIb/IIIa receptor antagonists and other antiplatelet drugs, direct thrombin inhibitors, vasopressors, vasodilators, and fibrinolytic and antiarrhythmic agents
18. Understand the indications for and the mechanisms of action of mechanical circulatory support devices
19. Understand the indications for and complications of vascular closure devices

#### Level 1 Technical Skills

1. Perform percutaneous vascular access from the femoral artery and vein and subclavian or internal jugular vein



2. Perform right heart catheterization using a balloon flotation catheter
3. Perform temporary right ventricular pacemaker insertion
4. Perform left heart catheterization and coronary angiography of native arteries (using standard views) and left ventriculography under supervision

### Level 2 Cognitive Knowledge

1. All Level 1 items
2. Understand radiologic imaging, including design and operation of X-ray cineradiographic units, digital imaging and storage, radiation physics, factors influencing image quality, radiation quality assurance, and physiology of X-ray contrast media
3. Understand the basic operation of physiologic recorders, pressure transducers, oximeters, and oxygen consumption measurement equipment
4. Understand coronary physiology using techniques such as Doppler flow and fractional flow reserve
5. Understand the indications for and methods of performing trans-septal catheterization
6. Acquire knowledge of peripheral vascular anatomy and understand the indications and complications of peripheral vascular angiography

### Level 2 Technical Skills

1. All Level 1 items
2. Perform vascular access from the femoral, radial, or brachial route
3. Perform left heart catheterization and coronary angiography, as well as visualization of venous bypass and internal mammary and radial artery grafts
4. Perform angiography of the cardiac chambers (in addition to the left ventricle) and aorta
5. Perform intra-aortic balloon insertion and operate a balloon pump
6. Perform cardiac catheterization in common types of valvular, adult congenital, and cardiomyopathic heart disease
7. Perform pericardiocentesis, preferably under echocardiographic guidance
8. Perform right ventricular endomyocardial biopsy
9. Perform vascular closure device insertion
10. Perform aortography and femoral artery angiography

### Level 3 Cognitive Knowledge and Technical Skills

The trainee should possess the cognitive knowledge and technical skills outlined in the previously published ACC training statement (2). In addition, the trainee should acquire knowledge about trans-septal catheterization, percutaneous management of access site complications, and management of other complications of including but not limited to coronary perforation, no reflow (and its prevention), and stent thrombosis. The trainee should obtain a core experience in balloon angioplasty, intracoronary stents, atherectomy techniques, distal (and proximal) protection

devices, intravascular ultrasound, and measurement of fractional flow reserve. Familiarity with noncoronary (peripheral) angiography and intervention should be encouraged.

## Conferences

### Levels 1 and 2

All trainees must attend a regular cardiac catheterization conference. This may be a combined medical/surgical conference. The conference must present hemodynamic and angiographic data that are discussed in context with history, physical examination, and noninvasive findings. Indications, complications, and management strategies should also be discussed. It is particularly important that the Level 1 and 2 curriculum focus on teaching hemodynamics, cardiovascular physiology, and the pathophysiology of the major cardiovascular disorders. In this role, it is important that the cardiac catheterization program establish a close liaison with other noninvasive diagnostic laboratories, particularly the echocardiography laboratory. The educational program should emphasize the relationships between the findings provided by the different diagnostic modalities in order to create a clear picture of the physiology and pathophysiology of the various cardiovascular disorders. A regular morbidity and mortality conference, either as part of the cardiac catheterization conference or as a separate conference, is also required.

### Level 3

The interventional cardiology training program should conduct a regularly scheduled clinical interventional cardiology conference at least weekly (2) and journal club at least monthly.

### Research

All trainees should be exposed to the principles of research and to research conducted in the cardiac catheterization laboratory. For those who plan to perform independent catheterization and angiography, it is desirable that they actively participate in the research and attend research conferences that discuss such studies. Those planning a career in interventional cardiology must participate in research, either during their 3-year fellowship training or during their subsequent interventional training.

### Trainee Evaluation

Trainee evaluation involves 3 components: cognitive, technical, and documentary. Case selection and pre-, intra-, and post-procedural care and judgment must be evaluated in every trainee. Facilities that foster the trainee's involvement in the continuum of care (outpatient or inpatient) from pre-procedural assessment to post-procedural follow-up are required. In every trainee, interpretive skills that relate to assessment of complex hemodynamics, coronary angiographic images, and physiologic studies must also be eval-

uated. Quality of clinical follow-up, reliability, interaction with other physicians, patients, and laboratory support staff, and the initiative and ability to make independent, appropriate decisions are to be considered. The individual must have knowledge of the specific equipment to be used in each procedure, including X-ray contrast, diagnostic catheters, and potential closure devices. Assessment of technical performance is also a requirement. This is best done by direct oversight during procedures of actual handling of equipment and devices, by assessment of the interaction of the trainee with the device and specific anatomy being treated, and by procedural complication rate. The competence of all cardiology trainees in cardiac catheterization should be documented by both the cardiovascular program director and the program director of the cardiac catheterization laboratory. All procedures performed by the trainee must be documented electronically or in a logbook.

Responsibility for trainee evaluation resides with the catheterization laboratory program director, who performs the assessment of the success of the trainee's progress in collaboration with the other program faculty. The overall evaluation includes rigorous compilation of trainee experience and assessment of the trainee's cognitive knowledge, technical skill, and clinical and procedural judgment. Evaluative feedback, verbal and written, to the trainee on a

bi-annual basis during the training period is vital to direct the trainee's progress.

*This is a revision of the April 2002 document that was written by Alice K. Jacobs, MD, FACC—Chair; David P. Faxon, MD, FACC; John W. Hirshfeld, Jr., MD, FACC; and David R. Holmes, Jr., MD, FACC.*

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**Key Words:** ACCF Training Statement ■ COCATS 3 ■ diagnostic cardiac catheterization ■ interventional cardiac catheterization.

### APPENDIX 1. AUTHOR 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

Name	Consultant	Research Grant	Scientific Advisory Board	Speakers' Bureau	Steering Committee	Stock Holder	Other
Dr. Joseph D. Babb	None	None	None	None	None	• General Electric	None
Dr. John W. Hirshfeld, Jr.	None	• GE Healthcare	• Bracco Diagnostics	None	None	None	None
Dr. David R. Holmes, Jr.	None	None	None	None	None	None	None
Dr. Alice K. Jacobs	None	None	None	None	None	None	• Wyeth Pharmaceuticals— spouse's employer

This table represents the relationships of committee members with industry that were reported by the authors as relevant to this topic. It does not necessarily reflect relationships with industry at the time of publication.

**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**

Name*	Affiliation	Consultant	Research Grant	Scientific Advisory Board	Speakers' Bureau	Steering Committee	Stock Holder	Other
Dr. Rick A. Nishimura	• Official—Board of Trustees	None	None	None	None	None	None	None
Dr. Jeffrey J. Cavendish	• Official—Board of Governors	None	None	None	None	None	None	None
Dr. Jorge Gaspar	• Official—Board of Governors	None	None	None	None	None	None	None
Dr. Matthew R. Wolff	• Official—Board of Governors	None	None	None	None	None	None	None
Dr. Jose G. Diez	• Content—Cardiac Catheterization Committee	• Sanofi-Aventis	None	None	• Sanofi-Aventis	None	None	None
Dr. Leonard S. Dreifus	• Content—Electrophysiology Committee	• Merck • Wyeth Pharmaceuticals	None	None	None	None	None	None
Dr. Mazen Abu-Fadel	• Content—Cardiac Catheterization Committee	None	None	None	None	None	None	None
Dr. James J. Ferguson	• Content—Cardiac Catheterization Committee	None	None	None	None	None	None	None
Dr. Debabrata Mukherjee	• Content—Cardiac Catheterization Committee	None	None	None	None	None	None	None
Dr. Charanjit Singh Rihal	• Content—Prevention Committee	• Cordis	• Cardiac Dimensions	None	None	None	None	None
Dr. Thoralf M. Sundt	• Content—Cardiac Catheterization Committee	None	None	None	None	None	None	None

This table represents the relationships of peer reviewers with industry that were reported by the authors as relevant to this topic. It does not necessarily reflect relationships with industry at the time of publication. \*Names are listed in alphabetical order within each category of review.

**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

Level	Duration of Training (Months)	Cumulative Duration of Training (Months)	Minimal No. of TTE Exams Performed	Minimal No. of TTE Exams Interpreted	TEE and Special Procedures
1	3	3	75	150	Yes*
2	3	6	150 (75 Add'l)	300 (150 Add'l)	Yes†
3	6	12	300 (150 Add'l)	750 (450 Add'l)	Yes

\*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

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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)

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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)

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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 are necessary.

### **Level 3 Training (6 Months of Additional Training, at Least 150 Additional Examinations Personally Performed, at Least 450 Additional Examinations Interpreted)**

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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 continuing 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**

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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**

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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 assiduous 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**

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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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**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

Name	Consultant	Research Grant	Scientific Advisory Board	Speakers' Bureau	Steering Committee	Stock Holder	Other
Dr. William F. Armstrong	<ul style="list-style-type: none"> <li>• St. Jude Medical</li> <li>• Wyeth Pharmaceuticals</li> </ul>	None	None	None	None	None	<ul style="list-style-type: none"> <li>• Wyeth Pharmaceuticals (legal consultant)</li> </ul>
Dr. Bijoy K. Khandheria	None	None	None	None	None	None	None
Dr. Thomas Ryan	None	None	None	None	None	None	None

This table represents the relationships of committee members with industry that were reported by the authors as relevant to this topic. It does not necessarily reflect relationships with industry at the time of publication.

## APPENDIX 2. PEER REVIEWER RELATIONSHIPS WITH INDUSTRY—ACCF 2008 RECOMMENDATIONS FOR TRAINING IN ADULT CARDIOVASCULAR MEDICINE CORE CARDIOLOGY TRAINING (COCATS 3)—TASK FORCE 4: TRAINING IN ECHOCARDIOGRAPHY

Name*	Affiliation	Consultant	Research Grant	Scientific Advisory Board	Speakers' Bureau	Steering Committee	Stock Holder	Other
Dr. David J. Clardy	• Official—Board of Governors	None	None	None	None	None	None	None
Dr. Bibiana Cujec	• Official—Board of Governors	<ul style="list-style-type: none"> <li>• AstraZeneca</li> <li>• Biovail</li> <li>• GE Healthcare</li> <li>• Philips</li> </ul>	None	None	None	None	<ul style="list-style-type: none"> <li>• GlaxoSmithKline</li> <li>• Johnson &amp; Johnson</li> </ul>	None
Dr. Monica Escarzaga	• Official—Board of Governors	None	None	None	None	None	None	None
Dr. Gordon L. Fung	• Official—Board of Governors	None	None	None	<ul style="list-style-type: none"> <li>• AstraZeneca</li> <li>• CV Therapeutics</li> <li>• GlaxoSmithKline</li> <li>• Merck</li> <li>• Novartis</li> <li>• Pfizer</li> </ul>	None	None	None
Dr. Rick A. Nishimura	• Official—Board of Trustees	None	None	None	None	None	None	None
Dr. Chittur A. Sivaram	• Official—Board of Governors	• 3F Therapeutics	None	None	None	None	None	None
Dr. Arthur J. Labovitz	• Organizational—American Society of Echocardiography	None	<ul style="list-style-type: none"> <li>• Boehringer Ingelheim</li> <li>• Integrium</li> <li>• Sanofi-Synthelabo</li> </ul>	None	• Baxter	None	None	None
Susan E. Wieggers	• Organizational—American Society of Echocardiography	None	None	None	None	None	None	None

This table represents the relationships of peer reviewers with industry that were reported by the authors as relevant to this topic. It does not necessarily reflect relationships with industry at the time of publication. \*Names are listed in alphabetical order with each category of review.

## Task Force 5: Training in Nuclear Cardiology

*Endorsed by the American Society of Nuclear Cardiology*

Manuel D. Cerqueira, MD, FACC, *Chair*

Daniel S. Berman, MD, FACC, Marcelo F. Di Carli, MD, FACC,

Heinrich R. Schelbert, MD, PhD, FACC, Frans J. Th. Wackers, MD, PhD, FACC,

Kim Allan Williams, MD, FACC (*American Society of Nuclear Cardiology Representative*)

### Training in Nuclear Cardiology

Nuclear cardiology (Table 1) provides important diagnostic and prognostic information that is an essential part of the knowledge base required of the well-trained cardiologist for optimal management of the cardiovascular patient. Training of fellows in nuclear cardiology is divided into 3 levels:\*

- General (Level 1, 2 months): Makes trainee conversant with the field of nuclear cardiology for application in general clinical management of cardiovascular patients.
- Specialized (Level 2, 4, to 6 months): Provides trainee with special expertise to practice clinical nuclear cardiology.†

The recommendations of this Joint Task Force, made up of representatives of the American College of Cardiology Foundation (ACCF) and the American Society of Nuclear Cardiology (ASNC), have been approved by the governing bodies of the ACCF and ASNC in October 2007.

\*The issues of ongoing clinical competence and training or retraining of practicing cardiologists are beyond the scope of this document. The Certification Board of Nuclear Cardiology (CBNC) was established jointly by the American College of Cardiology and ASNC and assesses knowledge and mastery in the areas of radiation safety and the technical and clinical performance of nuclear cardiology procedures. For additional information, contact CBNC at 19562 Club House Road, Montgomery Village, MD 20886; <http://www.cbnc.org>.

†Level 2 and Level 3 training meet eligibility criteria for taking the Certification Board of Nuclear Cardiology examination and Nuclear Regulatory Commission (NRC) training and experience requirements to become an authorized user. The NRC establishes federal policy with regard to the medical use of nuclear reactor byproduct materials. Currently, there are 33 states that have applied and been approved by the NRC to self-regulate the use of radioactive materials, so called "Agreement States." The other 17 states and the District of Columbia are regulated by the federal policy. There is variation within the Agreement States in the training and experience requirements for physicians applying to become authorized users of radioactive materials for diagnostic testing. The NRC requires only that the Agreement State requirements be as stringent as the federal NRC policy, but states have the authority to make the requirements more stringent. Some states require a greater number of total hours for the didactic, classroom, and laboratory experience in radiation safety. Other states have restricted the acceptable programs or institutions where such training hours may be acquired. Given this variability in training and experience requirements within the U.S., trainees are advised to contact the NRC and the Agreement States where they may seek to become authorized users of radioactive materials for the current rules and requirements. For details contact the Agreement States Homepage at <http://www.hsrn.gov/nrc/home.html>. Click on Directory and then click on Directory of Agreement States and Non-Agreement State Directors and State Liaison Officers. This will provide information on contacting the individual states and getting the specific licensure requirements.

- Advanced (Level 3, 1 year): Provides advanced training sufficient to pursue an academic career or direct a nuclear cardiology laboratory.†

### General Cardiology Training Background

To have an adequate understanding of the clinical applications of nuclear cardiology and to perform tests safely, the cardiology trainee must acquire knowledge and proficiency in the following areas of general cardiology:

1. Coronary angiography and physiology
2. Cardiac physiology and pathophysiology
3. Rest and exercise electrocardiography
4. Exercise physiology
5. Pharmacology of standard cardiovascular drugs
6. Cardiopulmonary resuscitation and treatment of other cardiac emergencies
7. Pharmacology and physiology of commonly used stress agents, such as dipyridamole, adenosine, and dobutamine
8. Clinical outcomes assessment

### Overview of Nuclear Cardiology Training

Training in nuclear cardiology at all levels should provide an understanding of the indications and appropriate use of specific nuclear cardiology tests, the safe use of radionuclides, basics of instrumentation and image processing, methods of quality control, image interpretation, integration of risk factors, clinical symptoms and stress testing, and the appropriate application of the resultant diagnostic information for clinical management. The depth of understanding will vary with each of the 3 levels of training. Training in nuclear cardiology is best acquired in Accreditation Council for Graduate Medical Education (ACGME)-approved training programs in cardiology, nuclear medicine, or radiology. An exception to this ACGME requirement is the didactic and laboratory training in radiation safety and radioisotope handling that may be provided by qualified physicians/scientists in a non-ACGME program when such

**Table 1** Classification of Nuclear Cardiology Procedures

1. Standard nuclear cardiology procedures
  - a. Myocardial perfusion imaging
    - i. SPECT with technetium-99m agents and/or thallium-201, with or without attenuation correction
    - ii. PET with rubidium-82 and/or nitrogen-13 ammonia
    - iii. Planar with technetium-99m agents and/or thallium-201
    - iv. ECG gating of perfusion images for assessment of global and regional ventricular function
    - v. Imaging protocols
    - vi. Stress protocols
      1. Exercise stress
      2. Pharmacologic stress
    - vii. Viability assessment including reinjection and delayed imaging of thallium-201 and/or metabolic imaging where available
  - b. Equilibrium radionuclide angiocardiography and/or “first-pass” radionuclide angiography at rest
  - c. Qualitative and quantitative methods of image display and analysis
2. Less commonly used nuclear cardiology procedures
  - a. Combined myocardial perfusion imaging with cardiac CT for attenuation correction or anatomic localization
  - b. Equilibrium radionuclide angiocardiography and/or “first-pass” radionuclide angiography during exercise or pharmacologic stress
  - c. Metabolic imaging using single-photon and/or positron-emitting radionuclides
  - d. Myocardial infarct imaging
  - e. Cardiac shunt studies

CT = computed tomography; ECG = electrocardiogram; PET = positron emission tomography; SPECT = single-photon emission computed tomography.

a program is not available as part of the clinical ACGME training program. For laboratories that provide training to cardiology fellows, accreditation by the Intersocietal Commission for Accreditation of Nuclear Laboratories (ICANL) is also recommended.

Nuclear cardiology training consists of the components shown in Table 2. Didactic, clinical case experience, and hands-on training hours require documentation in a log-book, having the trainee’s name appear on the clinical report or having some other specific record. The hours need to be monitored and verified by the nuclear cardiology training preceptor. For the advanced trainee, specialized training and research can be derived as part of an established program in either cardiology or a division of nuclear medicine. The person(s) responsible for the didactic, clinical, and hands-on training and experience are responsible for evaluating the competence of the trainee in nuclear cardiology upon completion of the program. This can be accomplished by observing the daily performance of the fellow, a formal testing procedure, or both. The preceptor for Level 2 or Level 3 should be an authorized user recognized by the Nuclear Regulatory Commission (NRC) or an Agreement State, have Level 3 (or the equivalent) training in nuclear cardiology, and preferably be certified by the Certification Board of Nuclear Cardiology (CBNC).

**Didactic Program**

**Lectures and self-study.** This component consists of lectures on the basic aspects of nuclear cardiology and

parallel self-study material consisting of reading and viewing cases on video or CD-ROM. The lectures and reading should provide the fellow with an understanding of the clinical applications of nuclear cardiology, including imaging with positron-emitting radionuclides and computed tomography (CT) hybrid systems including single-photon emission computed tomography (SPECT)/CT and positron emission tomography (PET)/CT. The material covered should include radiopharmaceuticals, radiation physics instrumentation, nuclear cardiology diagnostic tests and procedures/protocols, general cardiology as it relates to image interpretation, risk stratification, myocardial perfusion imaging, ventricular function imaging, and assessment of myocardial viability. Specificity, sensitivity, diagnostic accuracy, utility in assessing prognoses and interventions, costs, indications, and pitfalls in interpretation and clinical application must be emphasized for each patient subset.

This program may be scheduled over a 12- to 24-month period, concurrent with other fellowship assignments. Some of the information can be effectively transmitted as part of a weekly noninvasive or invasive cardiology conference with presentation and discussion of nuclear cardiology image data.

**Radiation safety.** The second component of the didactic program should provide the fellow with an understanding of radiation safety as it relates to patient selection and administration of radiopharmaceuticals and utilization of CT systems. Fellows seeking Level 2 or Level 3 training will require greater in-depth knowledge as well as hands-on practical experience. These requirements are detailed for each level of training.

**Interpretation of Clinical Cases**

During training, fellows should actively participate in daily nuclear cardiology study interpretation under the direction of a qualified preceptor in nuclear cardiology. For all studies in which angiographic or hemodynamic data are available, such information should be correlated with the nuclear

**Table 2** Nuclear Cardiology Training Components

1. Didactic program
  - a. Lectures and self-study
  - b. Radiation safety
2. Interpretation of clinical cases
3. Hands-on experience
  - a. Clinical cases
  - b. Radiation safety

cardiology studies. Although experience in all aspects of nuclear cardiology is recommended, some procedures may not be available—or may be performed in low volume—in some training programs. Under such circumstances, an adequate background for general fellowship training can be satisfied with appropriate reading or review of case files. Training in nuclear cardiology needs to include extensive experience with the standard nuclear cardiology procedures and as much exposure as possible with the less commonly performed procedures. The training program needs to provide a teaching file consisting of perfusion and ventricular function studies with angiographic documentation of disease.

### Hands-On Experience

**Clinical cases.** Fellows should have hands-on supervised experience in an appropriate number of the standard procedures (e.g., myocardial perfusion imaging and radionuclide angiography) and as many of the less commonly performed procedures as possible. Such experience should include pre-test patient evaluation; radiopharmaceutical preparation—measuring the dose, administration, and experience with relevant radionuclide generators; operation and quality control of planar and SPECT gamma camera and PET and CT systems; setup of the imaging computer; utilization of ECG gating; performing treadmill, bicycle, and pharmacologic stress testing techniques; processing the data for display; interpreting the study; and generating a clinical report. Complete nuclear cardiology studies should be performed under the supervision of qualified personnel.

**Radiation safety.** Fellows need to be familiar with radiation biology and the regulations governing the use of radioactive materials and ionizing radiation for performing diagnostic nuclear cardiology and hybrid CT studies. This knowledge includes details for protecting patients, the public, and the user from the effects of radiation.

### General Training—Level 1 (Minimum of 2 Months)

The trainee is exposed to the fundamentals of nuclear cardiology for a minimum period of 2 months during training. This 2-month experience provides familiarity with nuclear cardiology technology and its clinical applications in the general clinical practice of adult cardiology, but it is not sufficient for the specific practice of nuclear cardiology. The 3 components of training include a didactic program that includes lectures, self-study, radiation safety and regulations, interpretation of nuclear cardiology studies, and hands-on experience.

#### Didactic Program

**Lectures and self-study.** This component consists of lectures on the basic aspects of nuclear cardiology and parallel self-study material consisting of reading and viewing case files. The material presented should integrate the role of

nuclear cardiology into total patient management. Such information can be included within a weekly noninvasive or invasive cardiology conference, with presentation and discussion of nuclear cardiology image data as part of diagnostic and therapeutic management.

**Knowledge and appreciation of radiation safety.** The didactic program should include reading and practical experience with the effects of radiation and provide the fellow with an understanding of radiation safety as it relates to patient selection and administration of radiopharmaceuticals and utilization of CT systems.

### Interpretation of Nuclear Cardiology Studies

During the 2-month rotation, fellows should actively participate in daily nuclear cardiology study interpretation (minimum of 100 cases). Experience in all the areas listed in Table 1 is recommended. If some procedures are not available or are performed in low volume, an adequate background for general fellowship training can be satisfied by appropriate reading or review of case files. The teaching file should consist of perfusion and ventricular function studies with angiographic/cardiac catheterization documentation of disease.

### Hands-On Experience

Fellows should perform complete nuclear cardiology studies alongside a qualified technologist or other qualified laboratory personnel. They should, under supervision, observe and participate in a large number of the standard procedures and as many of the less commonly performed procedures as possible. Fellows should have experience in the practical aspects of radiation safety associated with performing clinical patient studies.

### Specialized Training—Level 2 (Minimum of 4 Months)

Fellows who wish to practice the specialty of nuclear cardiology are required to have at least 4 months of training. Level 2 training includes a minimum of 700 h of radiation safety experience in nuclear cardiology. There needs to be didactic, clinical study interpretation, and hands-on involvement in clinical cases. In training programs with a high volume of procedures, clinical experience may be acquired in as short a period as 4 months. In programs with a lower volume of procedures, a total of 6 months of clinical experience will be necessary to achieve Level 2 competency. The additional training required of Level 2 trainees is to enhance their clinical skills, knowledge, and hands-on experience in radiation safety and qualify them to become authorized users of radioactive materials in accordance with the regulations of the NRC and/or the Agreement States.†



## Didactic

**Lectures and self-study.** The didactic training should include in-depth details of all aspects of the procedures listed in Table 1. This program may be scheduled over a 12- to 24-month period concurrent and integrated with other fellowship assignments.

**Radiation safety.** Classroom and laboratory training needs to include extensive review of radiation physics and instrumentation, radiation protection, mathematics pertaining to the use and measurement of radioactivity, chemistry of byproduct material for medical use, radiation biology, the effects of ionizing radiation, and radiopharmaceuticals. There should be a thorough review of regulations dealing with radiation safety for the use of radiopharmaceuticals and ionizing radiation. This experience should total a minimum of 100 cases and be separately documented.

## Interpretation of Clinical Cases

Fellows should participate in the interpretation of all nuclear cardiology imaging data for the 4- to 6-month training period. It is imperative that the fellows have experience in correlating catheterization or CT angiographic data with radionuclide-derived data for a minimum of 30 patients. A teaching conference in which the fellow presents the clinical material and nuclear cardiology results is an appropriate forum for such experience. A total of 300 cases should be interpreted under preceptor supervision, from direct patient studies (Table 3).

## Hands-On Experience

**Clinical cases.** Fellows acquiring Level 2 training should have hands-on supervised experience with a minimum of 35 patients: 25 patients with myocardial perfusion imaging and 10 patients with radionuclide angiography. Such experience should include pre-test patient evaluation; radiopharmaceutical preparation (including experience with relevant radionuclide generators and CT systems); performance of studies with and without attenuation correction; administration of the dosage, calibration, and setup of the gamma camera and CT system; setup of the imaging computer; processing the data for display; interpretation of the studies; and generating clinical reports.

**Radiation safety work experience.** This experience should total 620 h and be acquired during training in the clinical environment where radioactive materials are being used and under the supervision of an authorized user who meets the

NRC requirements of Part 35.290 or Part 35.290(c)(ii)(G) and Part 35.390 or the equivalent Agreement State requirements, and must include:

- a. Ordering, receiving, and unpacking radioactive materials safely and performing the related radiation surveys;
- b. Performing quality control procedures on instruments used to determine the activity of dosages and performing checks for proper operation of survey meters;
- c. Calculating, measuring, and safely preparing patient or human research subject dosages;
- d. Using administrative controls to prevent a medical event involving the use of unsealed byproduct material;
- e. Using procedures to safely contain spilled radioactive material and using proper decontamination procedures;
- f. Administering dosages of radioactive material to patients or human research subjects; and
- g. Eluting generator systems appropriate for preparation of radioactive drugs for imaging and localization studies, measuring and testing the eluate for radionuclide purity, and processing the eluate with reagent kits to prepare labeled radioactive drugs.

## Additional Experience

The training program for Level 2 must also provide experience in computer methods for analysis. This should include perfusion and functional data derived from thallium or technetium agents and ejection fraction and regional wall motion measurements from radionuclide angiographic studies.

## Advanced Training—Level 3 (Minimum of 1 Year)

For fellows planning an academic career in nuclear cardiology or a career directing a clinical nuclear cardiology laboratory, an extended program is required. This may be part of the standard 3-year cardiology fellowship. In addition to the recommended program for Level 2, the Level 3 program should include advanced quality control of nuclear cardiology studies and active participation and responsibility in ongoing laboratory or clinical research. In parallel with participation in a research program, the trainee should participate in clinical imaging activities for the total training period of 12 months, to include supervised interpretative experience in a minimum of 600 cases. Hands-on experience should be similar to, or greater than, that required for Level 2 training. The fellow should be trained in most of the following areas:

- Qualitative interpretation of standard nuclear cardiology studies, including SPECT and/or PET myocardial perfusion imaging, ECG-gated perfusion studies, attenuation-corrected studies, gated-equilibrium studies, “first-pass,”

**Table 3** Summary of Training Requirements for Nuclear Cardiology

Level	Minimum Duration of Training (Months)	Total No. of Examinations
1	2	100*
2	4–6	300*
3	12	600*

\*A minimum of 35 cases with hands-on experience must be performed and interpreted under supervision.

and any of the less commonly performed procedures available at the institution

- Quantitative analysis of SPECT and/or PET myocardial perfusion and/or metabolic studies
- Quantitative radionuclide angiographic and gated-myocardial perfusion analyses, including measurement of global and regional ventricular function
- SPECT and/or PET perfusion acquisition, reconstruction, and display
- ECG-gated SPECT and/or perfusion acquisition, analysis, and display of functional data
- Imaging of positron-emitting tracers using dedicated PET systems or hybrid PET/CT systems

The requirements for Level 1 to 3 training in nuclear cardiology are summarized in [Table 3](#).

### **Specific Training in Cardiac Imaging of Positron-Emitting Radionuclides**

Cardiac PET and PET/CT imaging of positron-emitting radionuclides are part of nuclear cardiology. An increasing number of nuclear laboratories have access to both conventional SPECT and PET imaging. For institutions that have positron-imaging devices, training guidelines are appropriate. Training in this particular imaging technology should go hand-in-hand and may be concurrent with training in conventional nuclear cardiology. Such training should include those aspects that are unique or specific to the imaging of positron-emitting radionuclides. Depending on the desired level of expertise, training in cardiac PET and imaging with positron-emitting radionuclides should include knowledge of substrate metabolism in the normal and diseased heart; knowledge of positron-emitting tracers for blood flow, metabolism and neuronal activity, medical cyclotrons, radioisotope production, and radiotracer synthesis; and principles of tracer kinetics and their in vivo application for the noninvasive measurements of regional, metabolic, and functional processes. The training should also include the physics of positron decay, aspects of imaging instrumentation specific to the imaging of positron emitters and the use of CT, production of radiopharmaceutical agents, quality control, handling of ultra-short life radioisotopes, appropriate radiation protection and safety, and regulatory aspects.

Consistent with the training guidelines for general nuclear cardiology, training should be divided into 3 classes.

#### **General Training (2 Months)**

This level is for cardiology fellows who are associated with an institution where PET and/or PET/CT devices are available and who wish to become conversant with cardiac positron imaging. Training should therefore be the same as for Level 1 training in nuclear cardiology but should include aspects specific to cardiac positron imaging. The additional proficiency to be acquired by physician trainees includes

background in substrate metabolism, patient standardization and problems related to diabetes mellitus and lipid disorders, positron-emitting tracers of flow and metabolism, and technical aspects of positron and CT imaging. A didactic program should include the interpretation of cardiac PET studies of myocardial blood flow and substrate metabolism, the interpretation of studies combining SPECT for evaluation of blood flow with PET for evaluation of metabolism, the evaluation of diagnostic accuracy and cost-effectiveness of viability assessment of coronary artery disease detection, and the understanding of radiation safety as specifically related to positron emitters. Hands-on experience should include supervised observation and interpretation of cardiac studies performed with positron-emitting radionuclides and PET and PET/CT imaging devices.

#### **Specialized Training (Minimum of 4 Months)**

This level of training is for fellows who wish to perform and interpret cardiac PET or positron imaging studies in addition to nuclear cardiology. This training should include all Level 1 and Level 2 training in nuclear cardiology (4 to 6 months) as well as general training for cardiac PET and PET/CT. Specific aspects of training for PET and for using positron-emitting radionuclides should include radiation dosimetry, radiation protection and safety, dose calibration, physical decay rates of radioisotopes, handling of large doses of high-energy radioactive materials of short physical half-lives, quality assurance procedures, and NRC safety and record-keeping requirements. This level of training requires direct patient experience with a minimum of 40 patient studies of myocardial perfusion, metabolism, or both.

#### **Advanced Training (Minimum 1 Year)**

This level of training is intended for fellows planning an academic career in cardiac PET or who wish to direct a clinical cardiac PET laboratory. Similar to Level 3 training in nuclear cardiology, this training should include active participation in laboratory and clinical research in parallel with clinical activities.

In addition to the requirements for general and specialized cardiac PET training (including standard nuclear cardiology training, as previously described), advanced training should include the following:

1. Basic principles of cyclotrons, isotope production, radiosynthesis, tracer kinetic principles and models, cardiac innervation and receptors, and methods for quantifying regional myocardial blood flow and substrate metabolism.
2. Imaging instrumentation including dedicated PET systems, hybrid PET/CT systems and SPECT-like positron imaging devices with high-energy photon collimators or coincidence detection. Image acquisition and processing to include review of sinograms, errors in image recon-

- struction, correction routines for photon attenuation, and patient misalignment.
3. Tissue kinetics of positron-emitting tracers; in vivo application of tracer kinetic principles; tracer kinetic models, generation of tissue time–activity curves, and computer-assisted calculation of region of functional processes of the myocardium.
  4. Computer-assisted data manipulation, quantitative image analysis, and image display.

### Hybrid Computed Tomography Imaging

Hybrid imaging devices combining PET or SPECT with CT are playing an increasing role in the field of cardiac imaging. Currently, nearly all PET scanners are sold as PET/CT devices, and SPECT/CT machines are now available from most manufacturers. As these devices become more widely disseminated, it will be important that training guidelines for their use be developed both for fellows in training and cardiologists already in practice. The applications of hybrid imaging in cardiology include the use of CT scanning to provide robust attenuation correction of SPECT or PET and to assess coronary calcium as a marker of coronary atherosclerosis. Even these noncontrast applications of hybrid imaging will require additional training beyond that required for CT alone. With CT coronary

calcium and SPECT or PET perfusion assessments, additional training will be needed regarding discordant results. With contrast injection, high resolution CT coronary angiography can be combined with rest/stress assessments of myocardial perfusion provided by PET and SPECT, allowing functional assessment of the anatomic findings. The specifics of the training required in hybrid imaging are beyond the scope of this document; nonetheless, those nuclear cardiology training programs that are equipped to perform hybrid imaging should incorporate training in this field in their programs. Training should include the physics of hybrid systems, CT attenuation correction, principles and application of CT coronary calcium assessment, and principles and application of CT coronary angiography.

*This is an update of the 2006 document that was written by Manuel D. Cerqueira, MD, FACC—Chair; Daniel S. Berman, MD, FACC; Marcelo F. Di Carli, MD, FACC; Heinrich R. Schelbert, MD, PhD, FACC; Frans J. Th. Wackers, MD, PhD, FACC; and Kim Allan Williams, MD, FACC (American Society of Nuclear Cardiology Representative).*

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**Key Words:** ACCF Training Statement ■ COCATS 3 ■ nuclear cardiology ■ electrocardiograph ■ computed tomography ■ positron emission tomography ■ single-photon emission computed tomography.

## APPENDIX 1. AUTHOR RELATIONSHIPS WITH INDUSTRY—ACCF 2008 RECOMMENDATIONS FOR TRAINING IN ADULT CARDIOVASCULAR MEDICINE CORE CARDIOLOGY TRAINING (COCATS 3)—TASK FORCE 5: TRAINING IN NUCLEAR CARDIOLOGY

Name	Consultant	Research Grant	Scientific Advisory Board	Speakers' Bureau	Steering Committee	Stock Holder	Other
Dr. Daniel S. Berman	• Tyco-Mallinckrodt	• Astellas • Bristol-Myers Squibb • GE Healthcare	• Spectrum Dynamics	None	None	• Spectrum Dynamics	• Cedars-Sinai Medical Center (Software royalties)
Dr. Manuel D. Cerqueira	None	• GE Healthcare	• Bristol-Myers Squibb • CV Therapeutics	• Astellas • Bristol-Myers Squibb • CV Therapeutics • GE Healthcare • Mallinckrodt	None	None	None
Dr. Marcelo F. Di Carli	• Bracco • Bristol-Myers Squibb Imaging • GE Healthcare	• Astellas • Bracco • Bristol-Myers Squibb Imaging • GE Healthcare	• Bracco • Bristol-Myers Squibb Imaging • GE Healthcare	• Astellas • Bracco • GE Healthcare	None	None	None
Dr. Heinrich R. Schelbert	None	None	None	None	None	None	None
Dr. Frans J. Th. Wackers	• Acusphere • GE Healthcare	• Acusphere • Astellas • Bristol-Myers Squibb • GE Healthcare	• King Pharmaceuticals	None	None	None	None
Dr. Kim Allan Williams	• King Pharmaceuticals	• Bristol-Myers Squibb • CV Therapeutics • GE Healthcare	• Bristol-Myers Squibb • GE Healthcare	• Astellas • GE Healthcare	None	None	None

This table represents the relationships of committee members with industry that were reported by the authors as relevant to this topic. It does not necessarily reflect relationships with industry at the time of publication.

**APPENDIX 2. PEER REVIEWER RELATIONSHIPS WITH INDUSTRY—ACCF 2008 RECOMMENDATIONS FOR TRAINING IN ADULT CARDIOVASCULAR MEDICINE CORE CARDIOLOGY TRAINING (COCATS 3)—TASK FORCE 5: TRAINING IN NUCLEAR CARDIOLOGY**

Name*	Affiliation	Consultant	Research Grant	Scientific Advisory Board	Speakers' Bureau	Steering Committee	Stock Holder	Other
Dr. David J. Clardy	• Official—Board of Trustees	None	None	None	None	None	None	None
Dr. Rick A. Nishimura	• Official—Board of Governors	None	None	None	None	None	None	None
Dr. James A. Arrighi	• Organizational—American Society of Nuclear Cardiology	None	None	None	None	None	None	None
Dr. Myron Craig Gerson	• Organizational—American Society of Nuclear Cardiology	None	None	None	None	None	None	None

This table represents the relationships of peer reviewers with industry that were reported by the authors as relevant to this topic. It does not necessarily reflect relationships with industry at the time of publication. \*Names are listed in alphabetical order with each category of review.

## Task Force 6: Training in Specialized Electrophysiology, Cardiac Pacing, and Arrhythmia Management

*Endorsed by the Heart Rhythm Society*

Gerald V. Naccarelli, MD, FACC, FHRS, *Chair*

Jamie B. Conti, MD, FACC, FHRS, John P. DiMarco, MD, PhD, FACC, FHRS,

Cynthia M. Tracy, MD, FACC, FHRS (*Heart Rhythm Society Representative*)

Clinical cardiac electrophysiology and cardiac pacing have merged into a common cardiac subspecialty discipline. Complex cardiac arrhythmias are managed by physicians with special expertise in cardiac electrophysiology, the use of cardiac implantable electrical devices (CIEDs), and the application of other interventional ablative techniques and pharmacologic treatments. Cardiac implantable electronic devices is a term used to encompass implantable cardioverter-defibrillators (ICDs), pacemakers, cardiac resynchronization therapy (CRT) devices, implantable hemodynamic monitors (IHMs), and implantable loop recorders (ILRs). For purposes of this document, IHMs and ILRs, while legitimately considered CIEDs, are excluded, and implantation numbers for these should not be considered as satisfying minimum training requirements.

The current Task Force is charged with updating previously published adult clinical cardiac electrophysiology training guidelines (1–4) based on changes in the cardiac electrophysiology field since the last revision (4). The number of procedures recommended for each level is a consensus based on published guidelines and competency statements and assumes

training by an appropriately trained mentor and documentation of satisfactory completion of such training by the program director. The number of procedures and duration of training are summarized in Tables 1 and 2.

### General Standards and Environment

#### Facilities and Faculty

Three organizations—the American College of Cardiology (ACC), the American Heart Association (AHA), and the Heart Rhythm Society (HRS)—have addressed training requirements and guidelines for permanent pacemaker selection, implantation, and follow-up (5,6); guidelines for the implantation and follow-up of ICDs in cardiovascular practice (7,8); guidelines for training in catheter ablation procedures (9,10); and teaching objectives for fellowship programs in clinical electrophysiology (11,12). The training recommendations for these 3 organizations are congruent and address new technologies, faculty, and facility requirements, as well as practice. It is strongly recommended that



**Table 1 Cardiac Arrhythmia and Electrophysiology Curriculum Training Summary**

Level	Curriculum/Skills	Time Requirement	Optional Training in Device Implantation
1	Cardiac arrhythmia and electrophysiology core	2 months (in addition to Task Force 2 training requirements)	No
2	Advanced noninvasive arrhythmia management	6 months	Yes: In addition to 6 months of noninvasive emphasis, another 6 months for a total of 12 months is required for pacemaker implantation training
3	Clinical invasive cardiac electrophysiology (meets the American Board of Internal Medicine CCEP Examination requirements)	1–2 years (12–24 months)	Yes: A total of 1 year beyond the 3-year cardiology training program is required. If surgical aspects of CIED implantation are desired, a total of 12 months will need to be devoted to this discipline.

CCEP = Clinical Cardiac Electrophysiology; CIED = cardiac implantable electrical device.

trainees who desire admission to the American Board of Internal Medicine (ABIM) examination for certification in cardiovascular diseases and those who seek admission to the clinical cardiac electrophysiology (CCEP) examination for certification of added qualifications in CCEP be certain to obtain specific requirements from the ABIM (13,14).

The cardiac arrhythmia aspects of a cardiology training program should meet the published recommendations and requirements regarding facilities and faculty (9,10). In order for trainees to be eligible for admission to the CCEP examination of the ABIM, training must take place in an Accreditation Council for Graduate Medical Education (ACGME)-approved training program (13). The intensity of training and the required teaching resources may vary according to the level of training provided. Facilities should be adequate to ensure a safe, sterile, and effective environment for invasive electrophysiologic studies and implantation of arrhythmia control devices. Faculty should include specialists who are skilled in the medical and surgical aspects of pacing and electrophysiology. In addition, faculty should be knowledgeable about the risks to the patient and to medical personnel from radiation exposure. Faculty responsible for training must be board certified in CCEP or possess equivalent qualifications. In addition, there must be a minimum of 2 key clinical CCEP faculty members,

including the program director. In programs with a total of more than 2 residents enrolled, a ratio of such faculty to residents of at least 1:1 must be maintained (13).

## Levels of Training

### Level 1

Within the cardiology core training program, Level 1 should comprise at least 2 months of CCEP rotation designed for cardiology trainees to acquire knowledge and experience in the diagnosis and management of bradyarrhythmias and tachyarrhythmias. Level 1 trainees still need to meet the requirements necessary for proper training in electrocardiography. Every cardiology trainee should learn the indications for and limitations of electrophysiologic studies, the ability to interpret intracardiac recordings such as AH, HV intervals and basic activation sequences during tachycardia, differentiation of a supraventricular and ventricular tachycardia, and the use of antitachycardia pacing to terminate tachyarrhythmias. Level 1 trainees should learn the proper use of antiarrhythmic agents, including drug interactions and proarrhythmic potential. In addition, Level 1 trainees should learn the appropriate indications for catheter ablation procedures. The Level 1 trainee should be exposed to noninvasive and invasive techniques related to the diagnosis and management of patients with cardiac arrhythmias that include ambulatory electrocardiographic monitoring (see the Task Force 2 recommendations), event recorders, ILRs, exercise testing for arrhythmia assessment, tilt-table testing, invasive electrophysiologic studies, and implantation of cardiac arrhythmia control devices. The electrocardiographic manifestations of arrhythmias should be taught on a regular basis during formal electrocardiogram (ECG) conferences. Additional experience in heart rhythm disorders and clinical correlations can be obtained from didactic sessions and conferences; however, they must be supplemented by rotation on an arrhythmia consultation service, during which time the trainee should gain first-hand experience as a consultant in arrhythmia management. Arrhythmias associated with congenital heart disease and

**Table 2 Core Cardiac Arrhythmia and Electrophysiology Curriculum Training**

Level	Minimal Number of Procedures	Cumulative Duration of Training (Months)
1	10 temporary pacemakers 10 cardioversions	2
2	100 CIED interrogations/programming	6
3	150+ EP cases 75 ablations 30–50 atrial fibrillation ablations 10+ trans-septal procedures 75 CIEDs (25 ICD, 25 dual-chamber devices, 25 CRT devices) 30 CIED revisions/replacements 200 CIED interrogations/programming (100 ICDs, 100 pacemakers)	12–24

CIED = cardiac implantable electrical device; CRT = cardiac resynchronization therapy; EP = electrophysiology; ICD = implantable cardioverter-defibrillator.

exposure to cardiac and noncardiac surgical procedures are important components of the arrhythmia core training.

The Level 1 cardiology trainee's experience should also include learning the fundamentals of cardiac pacing, recognizing normal and abnormal pacemaker function, indications for temporary and permanent pacing and the implantation of ICDs (4), pacing modes, and understanding basic techniques for interrogation, programming, and surveillance of pacemakers and ICDs. Trainees should learn the indications and limitations of biventricular pacing in patients with congestive heart failure.

The cardiology trainee should be formally instructed in and gain experience with the insertion, management, and follow-up of temporary pacemakers (4); measurement of pacing and sensing thresholds and recording of intracardiac electrograms for management of patients with temporary pacemakers; and indications and techniques for elective and emergency cardioversions (15). Temporary pacemaker and cardioversion exposure can be performed in other venues such as the cardiac catheterization laboratory or the critical care setting. Insertion of a minimum of 10 temporary pacemakers and performance of at least 10 elective cardioversions are required. The cardiology trainee should be formally instructed in and gain experience with the application of and use of transcutaneous pacing systems. These experiences can be obtained throughout the cardiovascular clinical training period.

### Level 2

Some trainees in cardiology may wish to acquire advanced training in the management of arrhythmias but not undertake training in all aspects of cardiac electrophysiology. Level 2 trainees should meet all Level 1 training requirements and should obtain advanced training in normal and abnormal cardiac electrophysiology and mechanisms of arrhythmias. Level 2 training consists of a minimum of 6 months of training in noninvasive arrhythmia management techniques designed to develop advanced competence and proficiency in the diagnosis, treatment, and longitudinal care of patients with complex arrhythmias. Exposure and proficiency in the performance and interpretation of other noninvasive tests related to the evaluation of patients who have arrhythmias should be part of the training. Level 2 trainees should have a thorough knowledge of the basic and clinical pharmacology of antiarrhythmic agents and demonstrate proficiency in their use.

Of special importance for the Level 2 trainee is the acquisition of skills and experience for managing inpatients and outpatients with complex cardiac arrhythmias, including programming and follow-up management of all types of bradycardia pacing, biventricular pacing, and ICD systems. The trainee is expected to function as the primary programming operator who interrogates, interprets, prescribes, and reprograms devices in at least 100 patients. The trainee at this level must also acquire advanced competency in temporary pacing, cardioversion, interpretation of invasive elec-

trophysiologic study data, and complex arrhythmia electrocardiograph interpretation.

Although the Level 2 trainee must have significant exposure to invasive electrophysiology, ICDs, and the surgical aspects of arrhythmia control device implantation, Level 2 training by itself does not qualify the trainee to perform these invasive procedures. The Level 2 trainee has the option of obtaining additional training in the surgical aspects of pacemaker implantation or may choose the additional training required for invasive cardiac electrophysiology, or both, as described under Level 3.

### Level 3

This level of training is designed for the individual who wishes to specialize in invasive diagnostic and therapeutic cardiac electrophysiology (16). Requirements of Levels 1 and 2 must be fully met. Prior procedure volume during Level 1 and Level 2 training is cumulative and counts towards the overall numbers to reach Level 3 training.

Clinical cardiac electrophysiology training includes a minimum of 4 years of training in clinical cardiology and electrophysiology. Current ACGME requirements specify a 3-year training program in general cardiology, which consists of a core 24-month clinical program and an additional 12 months, which may involve research and/or elective time in electrophysiology. A dedicated fourth year of training in CCEP after 3 years is required. The appropriate use, safe performance, and judicious interpretation of these complex procedures require highly specialized training and competence. Although CIED and invasive cardiac electrophysiology training including ablation is usually done concomitantly, sequential training is also acceptable as long as all of the requirements of training in this document are met. Furthermore, an advanced knowledge base in basic CCEP and pharmacology must provide a sound foundation for the acquisition of technical abilities and cognitive skills in the management of patients with complex arrhythmias.

To complete Level 3, in addition to Level 1 and 2 requirements, trainees should perform at least 150 electrophysiologic procedures and "be a primary operator and analyze 100 to 150 initial diagnostic studies. At least 50 to 75 of these procedures should involve patients with supraventricular arrhythmias. Because therapy with antiarrhythmic devices forms a major part of current electrophysiology practice, the trainee should also have been a primary operator during more than 25 electrophysiological evaluations of implantable antiarrhythmic devices" (17).

Electrophysiologic procedures should cover the total spectrum of arrhythmias, both supraventricular and ventricular tachyarrhythmias as well as bradyarrhythmias. Given the complexity of the field and the growing amount of information and new procedures, it is common for trainees to extend training for an additional year or more to gain advanced expertise in specific procedures, such as ischemic ventricular tachycardia, ablation of patients with congenital heart disease, and atrial fibrillation ablation procedures and

lead extractions. This type of advanced training can also be achieved during a post-training mentored practice.

Expertise in catheter placement, programmed electrical stimulation, endocardial mapping, catheter ablation, and interpretation of data must be ensured by the electrophysiology program director. The endocardial mapping experience should include some exposure to left heart mapping by the retrograde aortic approach. Training in trans-septal catheterization should be provided by an individual at the training institution with expertise in the technique. Experience with at least 10 trans-septal catheterization procedures is suggested as minimal required training. Participation in a minimum of 75 catheter ablations, including ablation and modification of the atrioventricular (AV) node, AV accessory pathways, atrial flutter, and atrial and ventricular tachycardia, is required (17). To gain expertise in atrial fibrillation ablation requires additional expertise in catheter manipulation and integration of knowledge related to 3-dimensional mapping systems. Given the rapid evolution of new mapping technologies, it is unlikely that the trainee will be exposed to all mapping technologies as part of their training. Trainees should be exposed to tools for definition of intracardiac anatomy, such as intravascular ultrasound, cardiovascular magnetic resonance, and computed tomography scans. No numeric guidelines have been established for training in atrial fibrillation ablation, but it is anticipated that the Level 3 trainee should participate in 30 to 50 mentored atrial fibrillation ablations, and data suggest that experience in 100 atrial fibrillation ablation procedures will minimize adverse effects (18).

Level 3 training in electrophysiology requires ICD experience that includes assisting with the primary device implantation, with electrophysiologic testing at the time of implantation, and with follow-up assessment. The trainee in electrophysiology also requires experience in left ventricular lead implantation procedures. The ICD implant exposure includes assisting with the device implantation, threshold, and defibrillation threshold (DFT) testing at the time of implant and follow-up. Full Level 3 recommendations for the implantation of CIEDs are explained in detail in the following text.

### **Optional Training in Device Implantation (Applicable to Level 2 or Level 3)**

Level 2 and 3 trainees may choose to obtain additional training in the surgical aspects of device implantation. The CIED implantation training may be obtained concurrently or sequentially with Level 2 or Level 3 training, respectively. For those cardiology trainees who elect to obtain proficiency in the surgical aspects of transvenous CIED implantation previous or concurrent Level 2 training is required. The CIED training must include development of expertise in permanent atrial right and left ventricular lead and ICD lead placement, threshold testing and programming of devices, principles of surgical asepsis, surgical techniques of implantation, and management of implant-related compli-

cations. Individuals receiving qualifying training in CIED implantation must participate as the primary operator (under direct supervision) in at least 75 CIED initial primary implantations. Primary implantations should include at least 25 ICD, 25 dual-chamber, and 25 CRT (either pacing or defibrillation) devices. Thorough ICD implant evaluation including ventricular fibrillation induction and defibrillation testing for a minimum of 25 implants is a necessary part of this training. Thirty CIED revisions or replacements, including at least 10 ICD revisions as the primary operator, is also a necessary requisite of this level of training. The trainee must also participate in the follow-up of at least 200 CIED patient visits and acquire proficiency in advanced pacemaker electrocardiography, interrogation, and programming of complex pacemakers. Of the follow-up visits, at least 100 should be in ICD and 100 in pacemaker patients. Level 2 training (6 months) with the option of training in pacemaker implantation (6 months) requires a total of 1 year of advanced training beyond the cardiology core Level 1. This may be obtained within a 3-year cardiology program if 1 of the 3 years is dedicated to acquiring pacemaker implantation skills plus related management and follow-up skills. This training does not meet the ABIM requirements for admission to the CCEP examination. As part of the training regarding implantable pacemakers, exposure to the indications, implantation techniques, and follow-up of implantable loop recorders is desirable.

The trainee pursuing a career in CCEP as addressed under Level 3 also has the option of obtaining expertise in the surgical aspects of pacemaker or transvenous ICD implantation, or both. The same amount of surgical experience with bradycardia pacemaker implantation is required and may be supplemented with surgical training for ICD implantation (15). If the Level 3 trainee chooses this option, he or she must participate as the primary implanter (under direct supervision) in at least 25 ICD system implantations, as well as possess the management and follow-up skills addressed under Level 3. The Level 3 trainee wishing to become proficient in implantation of biventricular pacing or defibrillating systems requires the aforementioned training and involvement in implantation and follow-up of 25 biventricular systems (5). He or she should be proficient at interpreting data gained from noninvasive tools, such as echocardiography, used in the evaluation of resynchronization therapies. Pacemaker lead extraction is a specialized procedure that requires special training but is not an obligate part of training for CCEP examination eligibility. Physicians being trained in lead extraction should perform a minimum of 20 lead extractions as the primary operator under the direct supervision of a qualified training physician (19).

Level 3 trainees for ICD implantation must have an extensive knowledge of ICD indications, contradictions, and management of complications; an ability to determine defibrillation thresholds and manage high defibrillation thresholds; an understanding of drug- and pacemaker-ICD



interactions; and a thorough knowledge of ICD programming and management of ICD malfunction and post-operative complications. Level 3 training with the option of pacemaker or ICD implantation or both requires a minimum of 1 year of dedicated CCEP and device implantation training beyond the 3-year cardiology program. In addition, Level 3 trainees must have an extensive knowledge of left ventricular lead indications, contraindications, and management of biventricular malfunctions and interactions, as well as post-operative complications. It has been advocated that physicians training in congestive heart failure/transplantation could pursue an additional year of training to achieve Level 2 and Level 3 competency in implantable devices by meeting all of the above COCATS training requirements (20). It is recommended that Level 3 fellowship training for ICD implantation follow the aforementioned COCATS requirements.

### Evaluation, Competence, and Privileges

The program director should maintain adequate records of each individual's training experiences and performance of various procedures for appropriate documentation for Levels 1, 2, and 3. The trainees should also maintain records of participation in the form of a logbook containing clinical information, procedure performed, and outcome of procedures, including any complications encountered.

The ACC, AHA, and HRS have formulated a clinical competence statement on invasive electrophysiology studies, catheter ablation, and cardioversion (17). Self-assessment programs and competence examinations in electrocardiography are available through the ACC and other organizations. Training directors and trainees are encouraged to utilize these resources.

The ACGME has published the essential components of a specialized program for training in CCEP. The ABIM provides a special examination for additional certification in CCEP. Information concerning the training requirements for admission to the examination can be obtained from the ABIM; such requirements include 1 additional year of training in an ACGME-accredited electrophysiology program. Subsequent privileges to perform invasive procedures should be granted primarily on the basis of the technical expertise acquired in the training program, the documented training, and the recommendations of the directors of electrophysiology/pacing programs.

The Heart Rhythm Society strongly recommends the COCATS Task Force 6 training requirements for CIEDs. As the Society's 2004 Clinical Competency Statement on Training Pathways for Implantation of Cardioverter Defibrillators and Cardiac Resynchronization Devices (21) and the 2005 Addendum (22) sunsets in October 2008, the Society recommends that physicians who wish to incorporate CIED implantation and follow-up into their clinical practice meet the training requirements described in this

document and passage of the International Board of Heart Rhythm Examiners' (IBHRE) Examination of Special Competency in Cardiac Pacing and Cardioversion Defibrillation for the Physician (23) and or the American Board of Internal Medicine CCEP Examination (for those who complete a CCEP fellowship, which demonstrate knowledge essential to the practice of heart rhythm management.

*This is a revision of the 2006 document that was written by Gerald V. Naccarelli, MD, FACC—Chair; Jamie B. Conti, MD, FACC; John P. DiMarco, MD, PhD, FACC; and Cynthia M. Tracy, MD, FACC (Heart Rhythm Society Representative).*

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**Key Words:** ACCF Training Statement ■ COCATS 3 ■ specialized electrophysiology ■ cardiac pacing ■ arrhythmia management ■ implantable devices ■ defibrillation ■ cardiac implantable electrical devices.

## APPENDIX 1. AUTHOR RELATIONSHIPS WITH INDUSTRY—ACCF 2008 RECOMMENDATIONS FOR TRAINING IN ADULT CARDIOVASCULAR MEDICINE CORE CARDIOLOGY TRAINING (COCATS 3)—TASK FORCE 6: TRAINING IN SPECIALIZED ELECTROPHYSIOLOGY, CARDIAC PACING, AND ARRHYTHMIA MANAGEMENT

Name	Consultant	Research Grant	Scientific Advisory Board	Speakers' Bureau	Steering Committee	Stock Holder	Other
Dr. Jamie B. Conti	None	<ul style="list-style-type: none"> <li>• Guidant</li> <li>• Medtronic</li> <li>• St. Jude Medical</li> </ul>	• St. Jude Medical	None	None	None	None
Dr. John P. DiMarco	<ul style="list-style-type: none"> <li>• Guidant</li> <li>• Medtronic</li> <li>• Novartis</li> <li>• St. Jude Medical</li> </ul>	<ul style="list-style-type: none"> <li>• Guidant</li> <li>• Medtronic</li> <li>• Sanofi-Aventis</li> </ul>	None	• Guidant	None	None	None
Dr. Gerald V. Naccarelli	<ul style="list-style-type: none"> <li>• AstraZeneca</li> <li>• Boehringer-Ingelheim</li> <li>• Cardiofocus</li> <li>• GlaxoSmithKline</li> <li>• Guidant</li> <li>• Medtronic</li> <li>• Sanofi-Aventis U.S.</li> <li>• Pharmaceuticals</li> <li>• Proctor &amp; Gamble</li> <li>• Reliant Pharmaceuticals</li> <li>• Wyeth Pharmaceuticals</li> <li>• Zention</li> </ul>	<ul style="list-style-type: none"> <li>• Boehringer-Ingelheim</li> <li>• Cardiome</li> <li>• Guidant</li> <li>• Medtronic</li> <li>• Sanofi-Aventis</li> <li>• Wyeth Pharmaceuticals</li> </ul>	None	None	None	None	None
Dr. Cynthia M. Tracy	None	None	None	None	None	None	None

This table represents the relationships of committee members with industry that were reported by the authors as relevant to this topic. It does not necessarily reflect relationships with industry at the time of publication.

## APPENDIX 2. PEER REVIEWER RELATIONSHIPS WITH INDUSTRY—ACCF 2008 RECOMMENDATIONS FOR TRAINING IN ADULT CARDIOVASCULAR MEDICINE CORE CARDIOLOGY TRAINING (COCATS 3)—TASK FORCE 6: TRAINING IN SPECIALIZED ELECTROPHYSIOLOGY, CARDIAC PACING, AND ARRHYTHMIA MANAGEMENT

Name*	Affiliation	Consultant	Research Grant	Scientific Advisory Board	Speakers' Bureau	Steering Committee	Stock Holder	Other
Dr. Rick A. Nishimura	• Official—Board of Trustees	None	None	None	None	None	None	None
Dr. Stuart A. Winston	• Official—Board of Governors	None	None	None	None	None	None	None
Dr. Anne B. Curtis	• Organizational—Heart Rhythm Society	• Biosense • Medtronic • St. Jude Medical • Webster	• Medtronic	None	• Boston Scientific • Medtronic • St. Jude Medical	None	None	None
Dr. Dwight W. Reynolds	• Organizational—Heart Rhythm Society	None	None	None	None	None	None	None
Dr. Peter R. Kowey	• Content—Electrophysiology Committee	None	None	None	None	None	None	None
Dr. Richard L. Page	• Content—Electrophysiology Committee	None	None	None	None	None	None	None
Dr. Claudio D. Schuger	• Content—Electrophysiology Committee	• Stereotaxis	• Guidant • Medtronic	None	None	None	• St Jude Medical	None

This table represents the relationships of peer reviewers with industry that were reported by the authors as relevant to this topic. It does not necessarily reflect relationships with industry at the time of publication. \*Names are listed in alphabetical order with each category of review.

## Task Force 7: Training in Cardiovascular Research

Joseph Loscalzo, MD, PhD, FACC, *Chair*

Gordon F. Tomaselli, MD, FACC, Douglas E. Vaughan, MD, FACC, Richard A. Walsh, MD, FACC

All cardiology training should be performed in institutions in which the opportunity to participate in research is available. The training site should be one that will provide an atmosphere of intellectual inquiry and support of the investigative process.

It is important that every cardiovascular trainee participate directly in research. Cardiology is a dynamic clinical field in which the rapid transfer of knowledge from basic and clinical research to clinical care will continue to occur. This pattern will only accelerate in the future. Cardiovascular research is defined in the broadest terms possible because recent history makes it abundantly clear that advances in the care of patients with cardiovascular disease have come from diverse areas of medical science. If the clinical cardiologist is to maintain clinical competence and improve clinical knowledge in step with the progress of the field, it is crucial to maintain a thorough understanding of the concepts, methods, and pitfalls of the research process.

Every trainee should have direct involvement in the practical aspects of research, with emphasis on learning of how to review published data, research design, data analysis, and logical deduction. The research experience plays a unique role in developing the skills in continuing self-education needed by all

cardiovascular specialists. Trainees contemplating a career in investigative cardiology bear a special responsibility to prepare effectively to advance understanding in the broad area of cardiovascular science and especially the clinical application of new knowledge.

### General Standards

#### Training Institution

The training institution must have staff and facilities for research. Opportunities for research for the trainees should be available not only within the clinical cardiovascular division but also within the basic biomedical science departments of the institution. Availability of expertise in epidemiological methods, outcome evaluation, biostatistics, and biomedical ethics is essential. Optimally, cardiovascular training should be performed in a university teaching hospital or similar institution. Where this is not feasible, an active ongoing affiliation with a university is essential.

## Preparation

Before their appointment, individual trainees should have appropriate preparation in the biological, epidemiological, and physical sciences basic to medicine. If additional course work is desirable and appropriate, it should be available, and trainees should be encouraged to avail themselves of it.

## Faculty

Faculty of the training program must include several members with proven skill as investigators, demonstrated by published original research in peer-reviewed journals. The critical mass of the faculty requires several cardiovascular investigators, not all of whom need to be clinical cardiologists. At least 1 full-time faculty member from each training program should have demonstrated skill as a clinical investigator.

## Content of Training Program

### Research “Tracks”

Research training will ordinarily take place in 1 of 3 “tracks”:

**Level 1**—Trainees entering the clinical practice of cardiovascular medicine.

**Level 2**—Trainees planning a commitment to teaching and clinical investigation.

**Level 3**—Trainees planning a substantive commitment to basic or clinically advanced cardiovascular research.

### Components of Research

The trainee should develop skills in at least the following areas:

1. *literature study*, to ascertain the exact state of knowledge before undertaking new investigation;
2. *formulation of hypothesis and specific goals*, ensuring that the hypothesis is testable, that the goals are appropriate, and that statistical power is achievable;
3. *development of the research plan and the protocol*, including study design, importance of appropriate controls in clinical investigation, and recruitment of subjects, ethical considerations, informed consent and protection of privacy, data collection modes, full description of procedures, and institutional approval of human investigation, where appropriate, and writing a research grant;
4. *data collection*, including preparation of routine data forms;

5. *development of analytic methods or procedural skills*, as required, and particularly the handling of artifacts, missing data, outliers, and statistical inference;
6. *presentation of results*, preferably both oral and written, emphasizing that no investigation is complete until it is reported as a full paper in peer-reviewed journals;
7. *risk–benefit analysis*, regarding both patient (subject) and societal risk–benefit; and
8. *research ethics*, recognition of key concepts in the conduction of responsible research including but not restricted to data acquisition/management and protection, conflicts of interest, publication practices, and authorship and scientific conduct.

## Clinical Investigation

Clinical investigation must be performed under the supervision of an experienced investigator and according to approved principles of biomedical ethics and institutional rules for patient protection. It must be recognized that clinical research is difficult because of the complexity of achieving valid scientific conclusions while working with a diverse population and simultaneously protecting the interests of each patient.

In the case of multicenter clinical trials, participation in the full range of activities outlined here is required. The clinician lacking expertise in these areas may be unable to interpret critical reports that have a direct bearing on his or her practice. New data may be accepted uncritically or important advances recognized tardily. The training program should provide frequent opportunities for faculty and trainees to review and analyze small- and large-scale clinical and basic research reports in depth.

## Duration of Research Training

For trainees planning careers in the clinical practice of cardiovascular medicine (Level 1), 6 to 12 months (and in many instances up to 18 to 24 months) should be devoted to a specific project or projects. This research can be undertaken concurrently with other nonlaboratory clinical training and may not require a dedicated block of time. For those planning a substantive commitment to teaching and clinical investigation (Level 2), a minimum of 18 to 24 months should be devoted to clinical research. For those planning a substantive commitment to advanced clinical research (Level 3), a minimum of 2 full years should be devoted to mentored clinical research of which at least 1 year could

**Table 1** Summary of Training Requirements for Cardiovascular Research

Task Force	Area	Level	Minimal Number of Procedures	Cumulative Duration of Training (Months)	Minimal Cumulative Number of Cases	Comments
7	Research	1		6 to 12*		*Can be taken as part of 9 months of required nonlaboratory clinical practice rotation
		2		24		
		3		24 to 36		

occur during fellowship training. Training requirements for Levels 1, 2, and 3 are summarized in Table 1.

### Basic Research

For those planning a career in basic research (Level 3), 2 to 3 full-time years working directly with an experienced mentor are now needed in most cases. Such training constitutes only the beginning of the education of an independent cardiovascular investigator.

### Advanced Training for Trainees Considering Entering Investigative Cardiology

Trainees preparing for careers in research (Level 3) need an extensive foundation in scientific investigation. Some trainees will have obtained thorough research preparation in combined MD/PhD programs, but may lack the specific skills or tools that are appropriate to their personal research goals. These may be obtained in a post-doctoral research fellowship experience or as part of the cardiology traineeship. For full time training, the trainee should join the group or laboratory of a productive and active scientist, or clinical investigator (with an MD or PhD degree), in any qualified institution (not necessarily where he or she is obtaining direct training).

Trainees who aim for a career in investigative cardiology but who have not had the opportunity to obtain a PhD degree or equivalent training at the time they begin their cardiology traineeships should have the opportunity, and be encouraged, to obtain the necessary basic scientific analytic course work and laboratory or clinical research experience necessary for a productive research career. Current models of this type of training include the American Heart Association Clinician Scientist Award and the National Heart, Lung, and Blood Institute program for K08 (Mentored Clinical Scientist Development), K23 (Mentored Patient-Oriented Research Career Development), or K99/R00 (National Institutes of Health Pathway to Independence) awards.

### Teaching and Manuscript Review

It is important that the trainee be introduced to the basic principles and skills of education because almost all academic cardiologists devote a significant amount of time to teaching. It is highly desirable to provide opportunities for the critical review and analysis of manuscripts that have been published or are being considered for publication.

### Compensation

Compensation during the often prolonged period of research training should be sufficient to allow a full-time commitment to this training. Within this context, Congress recently passed the Clinical Research Enhancement Act, which mandates debt repayment for MDs or MD/PhDs engaging in research training.

## Evaluation

### Evaluation by the Training Director, Research Sponsor, or Both

Evaluation of a trainee's progress and skills should be subjective as well as objective, based on agreed-upon criteria and standards, and should be ongoing throughout the training period. The process and documentation currently required for admittance to the American Board of Internal Medicine Subspecialty Board Examination serves as a model for such evaluation. Each trainee's competence and understanding should be documented at the completion of training.

### Publication

Trainees should be encouraged to publish substantive results, thereby providing an evaluation by peer-reviewed journals.

### Flexibility

It must be appreciated that the education of future investigative cardiologists is a continuing process and that they usually remain in an educational institution where they are immersed in clinical cardiology. They often have unique demands that may require altering the sequence and exposure of clinical training, consistent with their previous clinical experience. Therefore, the program director should be afforded flexibility in the assignment of responsibilities for the years of training while guaranteeing full clinical competence.

## Summary

It is vital to the future intellectual health of cardiovascular medicine and the welfare of patients with cardiovascular disease that all future cardiologists be familiar with the principles and tools of research. Training in research requires the intense involvement of productive and established investigators. Those trainees preparing for a career in investigative cardiology require a carefully developed but flexible educational plan that will permit them to be successful in their research careers over an extended period.

*This is a revision of the 2002 document that was written by Robert Roberts, MD, FACC—Chair; R. Wayne Alexander, MD, PhD, FACC; Joseph Loscalzo, MD, FACC; and R. Sanders Williams, MD, FACC.*

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**Key Words:** ACCF Training Statement ■ COCATS 3 ■ cardiovascular research ■ investigative cardiology.



## APPENDIX 1. AUTHOR RELATIONSHIPS WITH INDUSTRY—ACCF 2008 RECOMMENDATIONS FOR TRAINING IN ADULT CARDIOVASCULAR MEDICINE CORE CARDIOLOGY TRAINING (COCATS 3)—TASK FORCE 7: TRAINING IN CARDIOVASCULAR RESEARCH

Name	Consultant	Research Grant	Scientific Advisory Board	Speakers' Bureau	Steering Committee	Stock Holder	Other
Dr. Joseph Loscalzo	None	None	None	None	None	None	None
Dr. Gordon F. Tomaselli	• Guidant • Pfizer	None	None	• Guidant • Medtronic	None	None	None
Dr. Douglas E. Vaughan	None	None	None	None	None	None	None
Dr. Richard A. Walsh	None	None	None	None	None	None	None

This table represents the relationships of committee members with industry that were reported by the authors as relevant to this topic. It does not necessarily reflect relationships with industry at the time of publication.

## APPENDIX 2. PEER REVIEWER RELATIONSHIPS WITH INDUSTRY—ACCF 2008 RECOMMENDATIONS FOR TRAINING IN ADULT CARDIOVASCULAR MEDICINE CORE CARDIOLOGY TRAINING (COCATS 3)—TASK FORCE 7: TRAINING IN CARDIOVASCULAR RESEARCH

Name	Affiliation	Consultant	Research Grant	Scientific Advisory Board	Speakers' Bureau	Steering Committee	Stock Holder	Other
Dr. Rick A. Nishimura	• Official—Board of Trustees	None	None	None	None	None	None	None
Dr. Chittur A. Sivaram	• Official—Board of Governors	• 3F Therapeutics	None	None	None	None	None	None

This table represents the relationships of peer reviewers with industry that were reported by the authors as relevant to this topic. It does not necessarily reflect relationships with industry at the time of publication.

## Task Force 8: Training in Heart Failure

*Endorsed by the Heart Failure Society of America*

James B. Young, MD, FACC, *Chair*  
 William T. Abraham, MD, FACC, Robert C. Bourge, MD, FACC,  
 Marvin A. Konstam, MD, FACC (*Heart Failure Society of America Representative*),  
 Lynne Warner Stevenson, MD, FACC

Recognition, evaluation, and treatment of heart failure are essential components of clinical cardiology practice. In order to achieve competency in this subject, 3 distinct training levels are defined, with curriculum outlined, in this section (1–4). All cardiology fellowship training programs will provide, at the least, a Level 1 curriculum in heart failure. More specifically, Level 1 training will provide an understanding of the depth and breadth of the heart failure syndrome, as well as nuances of therapy including the important topic of heart failure prevention. Level 2 training will be for those individuals who wish to broaden their experience with heart failure patients, particularly those with more advanced and challenging syndromes. This curriculum can, in particular, provide the opportunity to learn to manage devices (other than circulatory support systems)

implanted for heart failure therapy and arrhythmia or hemodynamic monitoring. Level 2 will also emphasize more detailed hemodynamic assessment of these patients. Level 3 training will be for those who anticipate focusing the majority of their subsequent clinical or research activities on the syndrome of heart failure with a curriculum requiring an additional 12 months of fellowship training above and beyond that required for cardiology specialization board examination. It is recognized that not all cardiology fellowship training programs will be capable of providing the most intense Level 3 training curriculum. Level 3 training will offer a range of programs that might, for example, include heart transplantation, mechanical circulatory support devices, and advanced heart failure electrophysiology, although not necessarily all of these.

This training scheme recognizes the fact that today, there is an ever-increasing number of treatments and interventions that improve outcomes and significantly alter the course of the heart failure syndrome. These treatments have generally increased the complexity of care, and it has become clear that there is a need for additional and special expertise to best effect and improve utilization of many heart failure evaluation and treatment strategies. It is also recognized that a significant portion of initial and follow-up care for heart failure patients will continue to be under the purview of general cardiologists and primary care clinicians; however, the more advanced Level 2 and 3 programs will provide increased sophistication and more skills necessary to manage advanced heart failure syndromes.

It is important to point out that Level 3 training and subsequent competency does not necessarily require the same level of experience with cardiac transplantation required for qualification as a heart transplant physician under United Network of Organ Sharing (UNOS) criteria (5). It is anticipated that a much broader group of individuals will be interested in establishing competency in advanced heart failure cardiology than will be directly managing patients undergoing cardiac transplantation. Nonetheless, many programs will offer an experience within the Level 3 curriculum that can establish heart transplant physician competency according to UNOS criteria. Furthermore, in developing Level 3 heart failure training criteria there was an expectation that, at some point in time, a secondary subspecialty of advanced heart failure management would likely evolve. Although timing for such a proposal moving forward is unclear, it is desirable to anticipate a curriculum that would qualify individuals for this distinction. The cumulative duration for training in heart failure will then be 1 month for Level 1 taken as part of 9 months of required nonlaboratory clinical practice rotation, and it is assumed that trainees will obtain additional training in heart failure preventive cardiovascular medicine beyond the 1-month core training as part of the experience during other clinical months such as consult services and the coronary care unit. Level 2 will require 6 months of dedicated rotations during the 36-month clinical cardiology training period, and Level

3 will require 12 months beyond the basic 36-month core training program (Table 1).

## Training in Heart Failure

### Level 1: General Training

The fundamental concepts of heart failure's pathophysiology and its treatment should be understood by all trainees in cardiovascular medicine as part of the core Level 1 training curriculum. Training in the clinical management of heart failure should include supervised experience in both inpatient and outpatient settings, and will expose the trainee to a broad spectrum of underlying causes of heart failure. Trainees should be well acquainted with the nuances of therapy for heart failure that are specific to different etiologies and should be well informed about the pharmacology of standard cardiovascular drugs used to treat heart failure. Trainees should be equally aware of the treatment strategies for patients with both chronic disease and acute exacerbations. An important element of the curriculum will be to train clinicians to appropriately refer heart failure patients for pacemaker, defibrillator, and percutaneous cardiovascular interventions; surgical procedures (including insertion of mechanical circulatory support devices); and cardiac transplantation.

### Heart Failure Level 1 Training Curriculum: Core Curriculum

The heart failure training Level 1 curriculum must include the following to ensure that trainees have formal instruction and clinical experience in the evaluation and management of patients from each of the following categories (it is anticipated that training programs will provide that experience in a creative combination of emergency department, inpatient, and outpatient settings):

1. Neurohormonal activation and its importance in the development of cardiovascular pathology and the syndrome of heart failure
2. The concept and significance of ventricular remodeling

**Table 1** Summary of Training Requirements for Heart Failure

Task Force	Area	Level	Minimal Number of Procedures	Cumulative Duration of Training (Months)	Minimal Cumulative Number of Cases	Comments
8	Heart failure and transplantation	1		1*†		*Can be taken as part of 9 months of required nonlaboratory clinical practice rotation. †It is assumed that trainees will obtain additional training in heart failure and preventive cardiovascular medicine beyond the 1-month core training as part of the experience during other clinical months, such as consult services and coronary care unit.
		2		6		
		3		12		

3. Cardiomyocyte biology as it applies to heart failure, focusing on the underlying abnormalities in the myocytes of the failing heart
4. Patients with heart failure with dilated or nondilated ventricles
5. Patients with new onset heart failure
6. Patients with acute decompensation of chronic heart failure
7. Geriatric patients with heart failure
8. Patients with heart failure associated with cancer chemotherapy
9. Patients with heart failure who are pregnant or recently post-partum
10. Patients with heart failure and congenital heart disease
11. Patients with heart failure representing diverse ethnic groups, with attention to specific diagnostic and therapeutic issues within these groups
12. Men and women with heart failure
13. Patients with heart failure before and after cardiac and noncardiac surgery
14. Patients with inherited forms of cardiomyopathy
15. Patients with hypertrophic cardiomyopathy
16. Patients with infiltrative and inflammatory cardiomyopathies
17. Patients with heart failure and atrial and ventricular arrhythmias
18. Patients with heart failure due to pulmonary pathology

These scenarios represent a broad and basic spectrum of clinical heart failure, and it is anticipated that most cardiology fellowship training programs will have the ability to meet this criteria. However, it is accepted that for some specific situations (i.e., heart failure patients with congenital heart disease or pregnancy-related heart failure states) clinical material may not be readily available. In those specific situations didactic training would be an acceptable substitute for formal inpatient or outpatient clinical exposure.

#### EVALUATION OF HEART FAILURE

With respect to evaluation of patients with heart failure, trainees must have formal instruction and clinical experience in the following specific areas:

1. Clinical trial evidence with respect to the diagnosis of heart failure
2. Clinical features (history and physical exam) in all forms and etiologies of heart failure
3. Application and interpretation of approaches to evaluating symptom severity, functional capacity, and health-related quality of life in patients with heart failure
4. Exercise physiology, including the role and interpretation of maximal and submaximal exercise testing and cardiopulmonary exercise testing
5. Indications for, and interpretation of, results of all diagnostic tests and modalities relevant to evaluation and management of patients with, or suspected of having, heart failure or cardiac dysfunction; in particu-

- lar, the impact of such testing on the management of these patients
6. Evaluation of the patient presenting with new onset heart failure and with acute exacerbation of chronic heart failure, including differential diagnosis, specific etiologies, and exacerbating factors
7. Role and interpretation of hemodynamic monitoring and its use in managing patients with new onset heart failure or exacerbation of chronic heart failure
8. Indications for referral of patients for mechanical circulatory support and cardiac transplantation
9. Indications for and evaluation of patients for implantation of left ventricular assist devices as destination therapy

#### HEART FAILURE MANAGEMENT

With respect to managing patients with heart failure, fellows must have formal instruction and clinical experience in the following specific areas:

1. Clinical trial evidence relevant to the management of heart failure
2. Indication, prescription, pharmacology, adverse effects, and appropriate monitoring of all classes of drugs relevant to the heart failure patient, including those known to benefit patients with heart failure, those suspected of benefiting patients with heart failure, and those known or suspected of adversely affecting patients with heart failure, in both the acute and chronic setting
3. Indication and prescription of nonpharmacologic/non-device treatment modalities in heart failure, including diet and exercise
4. Indications for cardiac transplant
5. Evidence for differences in appropriate management and response to therapy based on differences in etiology, cardiac structure and function, age, gender, ethnic background, and comorbidity
6. Impact of psychosocial factors on the manifestations, expression, and management of heart failure

#### PREVENTION OF HEART FAILURE

With respect to heart failure prevention, trainees must have formal instruction regarding conditions and factors known to predispose to, or exacerbate, heart failure syndromes. Specifically, a curriculum that emphasizes comprehensive cardiovascular risk factor modification more generally (e.g., prevention of atherosclerosis), and with respect to the heart failure syndrome, specifically, will be required.

#### Level 2: Intensified Experience in Heart Failure

Trainees who wish to have more training in advanced heart failure should be enrolled in programs that include specific outpatient clinics and inpatient services designed for patients requiring therapy for heart failure, as described for Level 1. However, such programs, in addition to ensuring a curriculum that satisfies the specifics of Level 1 training, also must offer a greater intensity and exposure to a broader spectrum of heart failure therapy modalities. Level 2 train-

ing can be accomplished within the scope of the 3 years of initial cardiology training. Trainees in a Level 2 curriculum should actively participate in didactic activities relating more specifically to heart failure, including research conferences, seminars, and journal clubs with the heart failure syndrome their primary focus.

### **Heart Failure Level 2 Training Curriculum: Additional Elements**

In addition to satisfying all Level 1 curriculum requirements outlined in the previous text, trainees will be required to have additional experiences in the interpretation of advanced heart failure patient hemodynamic data during both acute and chronic interventions and during the assessment of prognosis. One example of an additional curriculum at the Level 2 stage would be trainee rotations through outpatient electrophysiology clinics to focus on the interrogation, evaluation, and programming of implantable electrophysiologic devices used to treat and manage heart failure patients.

### **Level 3: Advanced Training in Heart Failure**

In addition to demonstrating proficiency in the specified and required Level 1 and elective Level 2 curriculum, advanced Level 3 training requires further demonstration of proficiency in additional arenas that include exposure to patients with more advanced or challenging heart failure conditions. Level 3 curriculum training will require an additional 12 months of training above and beyond that required for basic cardiology fellowship. A variety of curriculums can be created to satisfy Level 3 training requirements, but at the core of all will be the following required components:

#### **Basic Mechanisms of Heart Failure**

In addition to the curriculum specified in Level 1 training, fellows should have formal instruction and attain understanding of the following to be considered a more advanced Level 3 clinician:

1. More advanced training in cardiomyocyte and extracellular matrix biology, including calcium dysregulation; mechanisms of arrhythmia generation; beta-receptor abnormalities; mechanisms of apoptosis; metabolic abnormalities of the failing myocyte; and the roles of matrix remodeling in the progression of heart failure
2. Genetics, including a) common mutations leading to hypertrophic and dilated cardiomyopathies and b) an understanding of genetic polymorphisms related to myocardial disease and to targeted heart failure treatment

#### **Heart Failure Disease Management**

To qualify for heart failure Level 3 training, fellows must have a more in-depth and formal instruction in heart failure disease management, have clinical experience, and demonstrate proficiency as part of a multidisciplinary care team in

a clinical setting dedicated to heart failure. Managing multidisciplinary heart failure clinics and home-based care services is envisioned as a primary role of the advanced heart failure cardiologist, who should achieve proficiency in:

1. Specific behavioral strategies to enhance adherence to a heart failure therapeutic regimen
2. Supervision of home-based titration and monitoring of diuretics and neurohormonal antagonists with surveillance for renal dysfunction and electrolyte disturbances
3. The comprehensive education and counseling needs of heart failure patients and family members
4. Education and counseling strategies
5. The importance of nonpharmacologic, as well as pharmacologic, management
6. End-of-life care, including care options and participation in a multidisciplinary palliative care team
7. Assessment for quality of life, psychological problems (e.g., anxiety and depression), cognitive impairment, literacy problems, social isolation, financial problems, and other barriers to adherence and risk factors for rehospitalization
8. Management of heart failure with multiple comorbidities
9. Collaboration with nurses, dietitians, social workers, pharmacists, and other health professionals in the management of patients to stabilize or improve health status and prevent hospitalization
10. Transitional care principles, that is, facilitating communication between caregivers and physician extenders

#### **Clinical Research**

The heart failure Level 3 training assumes a more in-depth understanding of research in the heart failure field. Trainees at this level, therefore, should have a thorough knowledge and understanding of the principles of clinical research, sufficient to fully evaluate the validity and relevance of clinical research findings. This understanding should come from both didactic instruction and participation in clinical research projects as a trainee. Level 3 curriculum should ensure that training includes insight into:

1. Principles of informed consent and the ethical conduct of clinical research
2. Basic statistical methodologies, including sample size estimation and evaluation of significance
3. An understanding of the advantages and disadvantages of various clinical trial designs
4. Understanding of the various end points employed in clinical investigation in heart failure, including those employed for the measurement of clinical outcomes, functional status, and symptoms, as well as use of surrogate and composite end points
5. An understanding of the impact and interpretation of testing multiple end points simultaneously



## Expanded Heart Failure Populations

Advanced training further requires demonstration of proficiency in the management of additional more challenging cohorts of heart failure patients (with the specified levels of exposure listed in parentheses if meeting UNOS criteria as a “heart transplant physician” is desired). It is recognized that not all programs offering Level 3 training will have heart transplant or mechanical circulatory support programs that will satisfy UNOS criteria for heart transplant physician designation.

1. Patients requiring end-of-life hospice-based care
2. Patients with hemodynamic compromise severe enough to warrant chronic inotropic drug infusion support
3. Patients with heart failure and noncardiac organ transplants
4. Patients who are being evaluated for cardiac transplant or mechanical assist devices (at least 30)
5. Patients who have undergone cardiac transplant (at least 30, of whom at least 5 are seen during initial transplant hospitalization)
6. Patients with heart failure on mechanical circulatory assist devices (at least 5, of whom at least 2 are being managed during perioperative hospitalization)
7. Patients with heart failure being evaluated for implantable cardioverter-defibrillators (ICDs) (at least 50) and patients with heart failure being evaluated for cardiac resynchronization therapy (CRT) (at least 50)
8. Device interrogation and interpretation in patients with implanted ICD or ICD-CRT devices (at least 100)

## Additional Training Within a Level 3 Curriculum

For select individuals trained in advanced heart failure cardiology, it may be desirable to achieve additional training and credentialing. Examples of this include areas such as cardiac transplantation and mechanical circulatory support devices (as previously discussed), electrophysiologic device implants, and more sophisticated cardiovascular imaging. It is recognized that training programs may choose to incorporate opportunities for achieving competencies in these areas, either concurrently or consecutively with the 12-month Level 3 requirements, which are consistent with those training requirements specified elsewhere in this document. Further, as these fields evolve, combination programs may be established that are specifically designed to provide for joint competencies in these and other areas.

## Summary

Training in heart failure can be segregated into 3 distinct and ascending or tiered levels of intensity. Level 1 represents the basic training and competency that every cardiology fellowship trainee must experience and demonstrate. Level 2 training represents a significant intensification of training, so that a trainee can subsequently focus some of his or her subsequent clinical activities on heart failure patients or research. Level 3 training offers competencies required for individuals specializing in advanced heart failure cardiology. Such competency includes advanced training in such areas as cardiac transplantation, ventricular assist devices, and heart failure disease management. Many programs will offer exposure sufficient to qualify the trainee for the UNOS designation of heart transplant physician in the Level 3 curriculum. Within this rapidly evolving field, in which new diagnostic and treatment modalities are emerging, over time, additional competencies may be warranted to supplement present training and competency standards.

doi:10.1016/j.jacc.2007.11.016

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**Key Words:** ACCF Training Statement ■ COCATS 3 ■ heart failure ■ heart transplantation.

**APPENDIX 1. AUTHOR RELATIONSHIPS WITH INDUSTRY—ACCF 2008 RECOMMENDATIONS FOR TRAINING IN ADULT CARDIOVASCULAR MEDICINE CORE CARDIOLOGY TRAINING (COCATS 3)—TASK FORCE 8: TRAINING IN HEART FAILURE**

Name	Consultant	Research Grant	Scientific Advisory Board	Speakers' Bureau	Steering Committee	Stock Holder	Other	
Dr. William T. Abraham	<ul style="list-style-type: none"> <li>• Amgen</li> <li>• AstraZeneca</li> <li>• Boehringer-Ingelheim</li> <li>• CHF Solutions</li> <li>• GlaxoSmithKline</li> <li>• Guidant</li> <li>• Medtronic</li> <li>• Merck</li> <li>• Pfizer</li> <li>• ResMed Respironics</li> <li>• Scios</li> <li>• St. Jude Medical</li> </ul>	<ul style="list-style-type: none"> <li>• Amgen</li> <li>• Biotronik</li> <li>• CHF Solutions</li> <li>• GlaxoSmithKline</li> <li>• Heart Failure Society of America</li> <li>• National Institutes of Health</li> <li>• Maryland Research Institute</li> <li>• Medtronic</li> <li>• Myogen</li> <li>• Orqis Medical</li> <li>• Otsuka</li> <li>• Paracor</li> <li>• Scios</li> </ul>	<ul style="list-style-type: none"> <li>• CardioKine</li> <li>• CardioKinetix</li> <li>• CHF Solutions</li> <li>• Department of Veterans Affairs Coop Studies Program</li> <li>• National Institutes of Health</li> <li>• Savacor</li> <li>• Editorial Board Involvement: <i>Congestive Heart Failure</i></li> <li>• <i>Current Cardiology Reviews</i></li> <li>• <i>Current Heart Failure Reports</i></li> <li>• <i>Expert Review of Cardiovascular Therapy</i></li> <li>• <i>Journal Watch Cardiology</i></li> <li>• <i>PACE-Pacing and Clinical Electrophysiology</i></li> <li>• <i>The American Heart Hospital Journal</i></li> <li>• <i>The Journal of Heart Failure</i></li> </ul>	None	None	None	<ul style="list-style-type: none"> <li>• Honorarium Recipient—</li> <li>• AstraZeneca</li> <li>• Boehringer-Ingelheim</li> <li>• GlaxoSmithKline</li> <li>• Guidant</li> <li>• Medtronic</li> <li>• Merck</li> <li>• Pfizer</li> <li>• ResMed Respironics</li> <li>• Scios</li> <li>• St. Jude Medical</li> </ul>	
Dr. Robert C. Bourge	<ul style="list-style-type: none"> <li>• Medtronic</li> <li>• Orqis</li> <li>• Remon Technologies</li> <li>• United Therapeutics</li> <li>• Vasogen</li> </ul>	<ul style="list-style-type: none"> <li>• Medtronic</li> <li>• Orqis</li> <li>• Scios</li> <li>• United Therapeutics</li> <li>• Vasogen</li> </ul>	<ul style="list-style-type: none"> <li>• Medtronic</li> <li>• Orqis</li> <li>• United Therapeutics</li> <li>• Remon Technologies</li> <li>• Vasogen</li> </ul>	None	<ul style="list-style-type: none"> <li>• Medtronic</li> <li>• Orqis</li> <li>• Scios</li> <li>• Vasogen</li> </ul>	None	<ul style="list-style-type: none"> <li>• Stock options: Remon Technologies</li> </ul>	
Dr. Marvin A. Konstam	<ul style="list-style-type: none"> <li>• GlaxoSmithKline</li> <li>• Merck</li> <li>• Otsuka</li> <li>• Pfizer</li> </ul>	<ul style="list-style-type: none"> <li>• GlaxoSmithKline</li> <li>• Merck</li> <li>• Otsuka</li> <li>• Pfizer</li> </ul>	None	<ul style="list-style-type: none"> <li>• Medtronic</li> <li>• Pfizer</li> </ul>	None	<ul style="list-style-type: none"> <li>• Orqis Medical</li> </ul>	None	
Dr. Lynne Warner Stevenson	<ul style="list-style-type: none"> <li>• Medtronic</li> <li>• Scion</li> </ul>	None	None	None	None	None	None	
Dr. James B. Young	<ul style="list-style-type: none"> <li>• Amgen</li> <li>• AstraZeneca</li> <li>• Boehringer-Ingelheim</li> <li>• GlaxoSmithKline</li> <li>• Guidant</li> <li>• Medtronic</li> <li>• Protelix</li> <li>• Vasogen</li> </ul>	<ul style="list-style-type: none"> <li>• Amgen</li> <li>• AstraZeneca</li> <li>• Boehringer-Ingelheim</li> <li>• GlaxoSmithKline</li> <li>• Guidant</li> <li>• Medtronic</li> <li>• Vasogen</li> </ul>	None	None	None	<ul style="list-style-type: none"> <li>• Amgen</li> <li>• AstraZeneca</li> <li>• Boehringer-Ingelheim</li> <li>• GlaxoSmithKline</li> <li>• Medtronic</li> <li>• Protelix</li> <li>• Vasogen</li> </ul>	None	None

This table represents the relationships of committee members with industry that were reported by the authors as relevant to this topic. It does not necessarily reflect relationships with industry at the time of publication.

**APPENDIX 2. PEER REVIEWER RELATIONSHIPS WITH INDUSTRY—ACCF 2008 RECOMMENDATIONS FOR TRAINING IN ADULT CARDIOVASCULAR MEDICINE CORE CARDIOLOGY TRAINING (COCATS 3)—TASK FORCE 8: TRAINING IN HEART FAILURE**

Name*	Affiliation	Consultant	Research Grant	Scientific Advisory Board	Speakers' Bureau	Steering Committee	Stock Holder	Other
Dr. Rick A. Nishimura	• Official—Board of Trustees	None	None	None	None	None	None	None
Dr. Barry Greenberg	• Organizational—Heart Failure Society of America	• AstraZeneca • Boston Scientific • GlaxoSmithKline • Merck • NitroMed • Novartis • Scios	None	None	None	None	None	None
Dr. James A. Hill	• Content—Electrophysiology Committee	None	None	None	None	None	None	None
Dr. Maryl Johnson	• Content—Heart Failure Committee	• Astellas • CareMark	None	None	None	None	None	• Defense witness-2005
Dr. Mitchell T. Saltzberg	• Content—Heart Failure Committee	• CHF Solutions • Medtronic	None	None	• Guidant • Medtronic • Scios	None	None	• Institutional-CHF Solutions • Guidant • Medtronic • Scios
Dr. Richard J. Shemin	• Content—Heart Failure Committee	• Edwards Lifesciences • St. Jude Medical	None	None	None	None	None	None

This table represents the relationships of peer reviewers with industry that were reported by the authors as relevant to this topic. It does not necessarily reflect relationships with industry at the time of publication. \*Names are listed in alphabetical order with each category of review.

**Task Force 9: Training in the Care of Adult Patients With Congenital Heart Disease**

John S. Child, MD, FACC, *Chair*  
 Michael D. Freed, MD, FACC, Constantine Mavroudis, MD, FACC,  
 Douglas S. Moodie, MD, FACC, Amy L. Tucker, MD, FACC

Remarkable advances in surgical and catheter management of congenital heart disease (CHD) over the last half century have allowed greater than 85% of children with CHD to survive to adulthood (1). It is estimated that there are now over 1 million adult survivors with CHD in North America alone; thus, there are now more adults than children with CHD in the United States, and the number appears to be growing by about 5% per year (2). Adults with CHD have special health care needs and often present complex combinations of problems that are generally unrecognized by those in a traditional internal medicine-based cardiology training program (3). Medical cardiologists are experts in

the care of adult-acquired diseases that affect the heart and circulation, but currently most have little or no training in CHD, particularly in complex disorders. Adult CHD and clinical experiences for cardiology fellows vary widely (4). Many adults with CHD continue to be cared for by pediatric cardiologists because the numbers of medical cardiologists specializing in this complicated field are few and insufficient (5,6). This report suggests an approach to more systematic training of medical cardiologists in the recognition and care of adults with CHD based upon previous Bethesda Conference descriptions of workforce needs and educational requirements (6).

## Levels of Training

We differentiate 3 levels of training and expected expertise in the care of adult patients with CHD:

**Level 1 training** represents the level of knowledge appropriate for all trainees in medical cardiology and indicates the knowledge content that each graduate of such a program should acquire (6). This level of training should allow for sufficient knowledge to manage simple adult CHD and to recognize the moderate or complex diseases and obtain the appropriate consultations or referrals for proper care. This level of knowledge should be tested in the Subspecialty Certification Examination in Cardiovascular Diseases and will provide the graduate with sufficient expertise to recognize and evaluate common congenital heart disorders in adults. This expertise should include knowledge of the outcomes, residua, sequelae, and complications of medical management, of invasive catheter-based therapy, and of surgical palliation, correction, or repair. Specific disease categories of commonly treated disorders should be emphasized (see Post-operative residua/sequelae, Table 1). However, for trainees with Level 1 expertise, consultation with a pediatric cardiologist or Level 2- or Level 3-trained adult CHD cardiologist is advisable when major management decisions are made concerning patients with moderately to severely complex cardiac disease.

**Level 2 training** represents additional training for fellows who plan to care for adult patients with CHD so that they may acquire expertise in the clinical evaluation and management of such patients. Some exposure to pediatric cardiology is recommended. Level 2 training generally requires 1 year of training in adult CHD: either a 1-year formal program at a regional or tertiary care adult CHD center or cumulative experience of 12 months through repetitive rotations or electives as a cardiology fellow with experienced adult CHD cardiologists (6). Some consider-

ation can be given to those months spent learning CHD in general, be it in pediatric, adolescent, or adult CHD programs. This training should prepare the individual to be well-equipped for the routine care of even moderate to complex adult CHD and to recognize when more advanced consultation or referral is advisable.

**Level 3 training** represents the level of knowledge needed by those graduates who wish to make a clinical and academic/research commitment to this field and not only become competent in the care of the entire spectrum of adult patients with CHD but also participate in teaching and research of adult CHD (6). Some exposure to pediatric cardiology is recommended. Level 3 trainees generally require 2 years of training. These 24 months may either be contiguous or cumulative experience, and some recognition can be given to overall experience in CHD, be it pediatric, adolescent, or adult (e.g., prior pediatric cardiology training or rotations). It is probably preferable that at least 12 months of this training be contiguous in order to obtain both the maximum clinical continuity of care as well as sufficient time to dedicate to clinical research in the field. Such Level 3 training would be sufficient to clinically manage the most complex adult CHD in a regional or tertiary center, to pursue an academic career, to train others in the field, or to direct an adult CHD center program.

### Level 1: Basic Training for All Medical Cardiology Fellows

All medical cardiology trainees should be exposed to a core of information regarding adults with CHD. The goal of Level 1 training is for all graduates to be able to recognize and evaluate common, simple congenital heart lesions and the sequelae of the more commonly repaired congenital heart defects. These graduates should always consider consultation and collaborative patient management with a Level 2- or 3-trained specialist or pediatric cardiologist when major management decisions are made for adults with CHD and for periodic discussions of ongoing care.

We suggest that at least 6 h of formal lectures within the core curriculum of the training program be devoted to CHD in adults. Table 1 indicates the content suggested for these 6 h, covering key basic and clinical aspects of these disorders. A proposed curriculum is as follows: Hour 1 = basic embryology, anatomy, pathology, and physiology and known genetics of common lesions; Hour 2 = clinical diagnosis (history, exam, electrocardiogram, x-ray) and management of at least 6 common lesions expected to be encountered in adults, operated or not; Hour 3 = specific issues relevant to cyanotic CHD and Eisenmenger syndrome; Hour 4 = explanation of methods and outcomes of at least 6 usual surgical and catheter palliative and reparative techniques for CHD; Hour 5 = common echocardiographic features in operated and unoperated adult CHD; and Hour 6 = various topics which could include management during pregnancy, endocarditis prophylaxis, counseling on genetics and contraception, employment, and exer-

**Table 1** Level 1 Training in Congenital Heart Disease in Adults

Core Curriculum	Knowledge Areas
Basic science	Basic embryology, anatomy, pathology, physiology, genetics
Natural history/management	Clinical recognition and management of patients with common defects presenting in adulthood to include genetic counseling, care of pregnancy, and management during noncardiac surgery
Post-operative residua/sequelae	Includes but is not limited to specific diagnoses such as tetralogy of Fallot, atrial septal defects, ventricular septal defects, transposition of the great arteries (e.g., atrial baffle and arterial switch operations), single ventricle (e.g., Fontan operation), and ventricular outflow tract lesions (all levels of aortic and pulmonic stenosis and coarctation of the aorta)
Other	Indications for and access to local or regional expert consultation



cise. Within those 6 h of core curriculum, the trainees should be taught about the major outpatient management issues in adult CHD and when to consult or refer for more specialized advice. Current available modes of supplementing this education include readily available American College of Cardiology educational products (adult CHD section of the Adult Clinical Cardiology Self-Assessment Program and the Echocardiography Self-Assessment Program) or Web-based sites specific to CHD.

In addition to the didactic material in the core curriculum, trainees ideally should be exposed to adult patients with CHD on a regular basis. This could be done in the context of ongoing weekly case conferences usually already present in the medical cardiology training program. For example, at least 1 of the patients discussed in case conferences each month could be an adult with CHD. In addition, trainees are encouraged to become involved in an ongoing CHD outpatient clinic, to see older children or adolescents with a pediatric cardiology colleague, or both. If the training program does not have expertise in CHD or have access to CHD locally, partnering with an expert regional adult CHD facility for an elective rotation of 1 to 4 weeks total may be a valuable supplement.

Trainees should be exposed to the evaluation of CHD with various diagnostic modalities during usual clinical rotations (electrocardiography, electrophysiology, transthoracic and transesophageal echocardiography, nuclear cardiology, and the cardiac catheterization laboratory [including invasive transcatheter techniques]). Exposure to other advanced imaging techniques now commonly utilized in CHD (e.g., magnetic resonance imaging [MRI] and computed tomography [CT]) is highly desirable. Didactic material for these rotations should include materials on diagnosis and management of the adult with CHD.

### Level 2: Special Expertise in Adults With Congenital Heart Disease

At least 1 year of concentrated exposure is generally necessary for those trainees who have little or only basic prior knowledge of CHD and who wish to care independently for adult CHD patients. Table 2 indicates the knowledge areas that should be covered during this year's period.

In addition to didactic materials, the training should include the following activities and aims:

1. Participation in a regular (preferably one that meets more than once a week) outpatient clinic organized for the care of adults with CHD. The Level 2 trainee should be involved with the care of a minimum of 10 patients per week.
2. Participation in formal rotations in pediatric cardiology for either a total block of or cumulative equivalent of 1 to 2 months, including exposure to neonates and children with CHD via conferences, outpatient clinics, diagnostic laboratories (e.g., echocardiography, catheterization laboratory, and so on), and inpatient services

**Table 2** Level 2 Training in Congenital Heart Disease in Adults

Anatomy, physiology, clinical presentation, and natural history of specific lesions
Diagnostic methods
Physical examination
Electrocardiography
Significance of arrhythmias/electrophysiologic testing
Chest roentgenogram
Echocardiography, both transthoracic and transesophageal
Catheterization/angiography
Radionuclide angiography
Other advanced imaging methods; specifically CMR/CT
Therapeutic methods
Pharmacologic management
Surgical procedures
Catheter interventional procedures
Residua and sequelae of interventions (surgical and catheter)
Introduction to appropriate outpatient management
Reproduction issues
Counseling for pregnancy and management during pregnancy and delivery
Contraception
Evaluation for noncardiac surgery
Palliative care (e.g., management of pulmonary vascular obstructive disease)
Athletic and other activity counseling
Employment counseling and socioeconomic issues
Insurability
Psychosocial issues

CT = computed tomography; CMR = cardiovascular magnetic resonance.

including consultations and exposure to children with post-operative CHD in the intensive care unit. Given that such fellows will not likely be experienced in the critical care of pediatric patients, all inpatient participation should be observed and supervised by experienced pediatric cardiologists.

3. Acquisition of familiarity with the range of diagnostic and therapeutic methods, including direct experience in echocardiography, cardiac catheterization, and advanced imaging techniques (MRI and CT), and understanding of the applications of catheter-based techniques both for electrophysiologic mapping and arrhythmia ablation and for anatomic-hemodynamic intervention.
4. Participation in the perioperative care of patients with CHD (preferably in adults), including direct observation of surgical repair.
5. Engagement in the perioperative care of in-hospital patients with CHD with both cardiac and noncardiac medical and surgical issues.

### Program Requirements

Two basic requirements are indicated for a program to train effectively at Level 2: 1) the presence of associated formal programs in pediatric cardiology and cardiovascular surgery and 2) at least 1 faculty member with a career commitment to the care of adult patients with CHD (this faculty member should have achieved by either combined lifelong experience

**Table 3** Summary of Training Requirements for Care of Adult Patients With Congenital Heart Disease

Task Force	Area	Level	Minimal Number of Procedures	Cumulative Duration of Training (Months)	Minimal Cumulative Number of Cases	Comments
9	Congenital heart disease	1		Core lectures*		*Can be taken as part of 9 months of required nonlaboratory clinical practice rotation.
		2		12		
		3		24	40 catheterizations 300 TTE cases 50 TEE cases	

TEE = transesophageal echocardiography; TTE = transthoracic echocardiography.

of, or have been specifically trained in, the skills equivalent to Level 3 training).

### Level 3: Advanced Expertise in Adults With Congenital Heart Disease

To obtain a comprehensive understanding of all aspects of CHD, a 2-year program is recommended with continued participation in clinical practice relating to CHD. In addition to the aforementioned guidelines for Level 2 training, this training should include active participation in clinical and/or laboratory research in conjunction with clinical activities and direct participation in at least 40 diagnostic cardiac catheterization procedures in CHD, with trainees demonstrating a comprehensive understanding of the entire hemodynamic spectrum of anatomic abnormalities in CHD. Finally, trainees should interpret at least 300 transthoracic echocardiograms and 50 transesophageal echocardiographic examinations and have the ability to independently interpret such studies in a wide range of CHD (Table 3). The advanced trainee should also be trained in the interpretation of advanced imaging techniques (i.e., MRI and/or CT and angiography in CHD).

Because relatively few centers in the United States have amassed a sufficient number of adult CHD patients who have been followed up in an organized manner, regionalization of training in the care of the complex CHD patient is necessary (6).

### Trainee Evaluation and Documentation of Core Competence

For Level 1 training in CHD, the global Cardiology Fellowship Program Director shall: 1) either directly, or via an adult CHD faculty designee, attest to the clinical competence of each cardiology fellow; 2) administer a core competence written and/or oral exam at the finish or completion of the core 6 adult CHD lectures; 3) require

patient care log documentation of at least 50 supervised inpatient or outpatient encounters with patients with a primary diagnosis of some form of CHD during the core 3-year fellowship; and 4) log interpretation of at least 50 supervised adult CHD advanced cardiac diagnostic studies (cardiac catheterization, echocardiography, and/or cardiac MRI/CT procedures) during the core 3-year fellowship.

*This is a revision of the 2002 document that was originally written by Carole A. Warnes, MD, MRCP, FACC—Chair; Michael D. Freed, MD, FACC; Richard R. Liberthson, MD; and Constantine Mavroudis, MD, FACC.*

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### TASK FORCE 9 REFERENCES

- Perloff JK, Child JS. Congenital Heart Disease in Adults. 2nd edition. Philadelphia, PA: WB Saunders, 1998.
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**Key Words:** ACCF Training Statement ■ COCATS 3 ■ adult congenital heart disease.

## APPENDIX 1. AUTHOR RELATIONSHIPS WITH INDUSTRY—ACCF 2008 RECOMMENDATIONS FOR TRAINING IN ADULT CARDIOVASCULAR MEDICINE CORE CARDIOLOGY TRAINING (COCATS 3)—TASK FORCE 9: TRAINING IN THE CARE OF ADULT PATIENTS WITH CONGENITAL HEART DISEASE

Name	Consultant	Research Grant	Scientific Advisory Board	Speakers' Bureau	Steering Committee	Stock Holder	Other
Dr. John S. Child	None	None	None	None	None	None	None
Dr. Michael D. Freed	None	None	None	None	None	None	None
Dr. Constantine Mavroudis	None	None	None	None	None	None	None
Dr. Douglas S. Moodie	None	None	None	None	None	None	None
Dr. Amy L. Tucker	None	None	None	None	None	None	• Adenosine Therapeutics

This table represents the relationships of committee members with industry that were reported by the authors as relevant to this topic. It does not necessarily reflect relationships with industry at the time of publication.

## APPENDIX 2. PEER REVIEWER RELATIONSHIPS WITH INDUSTRY—ACCF 2008 RECOMMENDATIONS FOR TRAINING IN ADULT CARDIOVASCULAR MEDICINE CORE CARDIOLOGY TRAINING (COCATS 3)—TASK FORCE 9: TRAINING IN THE CARE OF ADULT PATIENTS WITH CONGENITAL HEART DISEASE

Name	Affiliation	Consultant	Research Grant	Scientific Advisory Board	Speakers' Bureau	Steering Committee	Stock Holder	Other
Dr. Rick A. Nishimura	• Official–Board of Trustees	None	None	None	None	None	None	None
Dr. Chittur A. Sivaram	• Official–Board of Governors	• 3F Therapeutics	None	None	None	None	None	None

This table represents the relationships of peer reviewers with industry that were reported by the authors as relevant to this topic. It does not necessarily reflect relationships with industry at the time of publication.

# Task Force 10: Training in Preventive Cardiovascular Medicine

Roger S. Blumenthal, MD, FACC, *Chair*  
C. Noel Bairey Merz, MD, FACC, Vera Bittner, MD, MSPH, FACC,  
Tyler J. Gluckman, MD, *Fellow-in-Training Member*

The missions of the American College of Cardiology and the American Heart Association have been to ensure optimal care to those with or at risk for developing cardiovascular disease (CVD). The cardiovascular specialist is expected to contribute significantly to the treatment and prevention of CVD in the setting of a rapidly growing field of knowledge ranging from molecular and cellular mechanisms to clinical outcomes. Over the past 2 decades, there have been dramatic increases in knowledge concerning specific risk factors in atherosclerosis, hypertension, thrombosis, and other forms of vascular dysfunction. Clinical trials have proven that strategies aimed at the appropriate detection and modification of risk factors can slow progression of atherosclerosis and hypertension and reduce the occurrence

of clinical events in both primary and secondary prevention settings. More recently, it has been shown that atherosclerosis can be stabilized or even modestly reversed. Finally, the growing knowledge base of molecular genetics applied to the study of the cardiovascular system has a potentially great relevance to the future clinical practice of preventive cardiovascular medicine.

Despite the fact that clinical outcomes can be improved by promotion of favorable life habits and behaviors and by the proper use of drug treatment, the application of preventive interventions in the clinical practice of cardiovascular medicine is not optimal. Prevention of CVD, in both the primary and secondary prevention setting, must no longer be peripheral to the practice of the cardiovascular specialist.

The cardiovascular specialist must become proficient in the primary and secondary prevention of CVDs, including the ability to recommend specific primary and secondary preventive measures and to identify patients with subclinical CVD who may benefit from more aggressive risk factor modification.

It is imperative that cardiovascular training programs provide the necessary education and training to promote best practices among their trainees, who bear the responsibility to provide optimal preventive services to their patients. This report outlines specific areas of knowledge and skills necessary to achieve this goal and also defines required and recommended standards to achieve this goal.

## General Standards and Environment

There should be adequate faculty, both in number and experience, to conduct a training program in preventive cardiovascular medicine. In addition to this, it is highly desirable for at least some of the faculty to have expertise in vascular biology, atherosclerosis, hypertension, disorders of lipid metabolism, obesity and weight management, diet and nutrition, smoking cessation, diabetes mellitus, thrombosis, clinical epidemiology, cardiac rehabilitation, clinical pharmacology, genetics, and the psychosocial aspects of CVD. Ideally, specific faculty in the cardiovascular medicine training program should be able to serve as topic-area experts in one or more of these specified areas. This is important because the faculty should be able to function as preventive cardiovascular medicine role models. Mentoring is important for cardiovascular trainees in their formative years, and prevention-oriented role models should function in this capacity.

## Content of the Training Program

Optimal knowledge and skills required for the practice of CVD prevention are extensive and can be divided into 3 levels.

### Level 1

Level 1 training should be required of all cardiovascular specialists and includes exposure to the following topics.

#### General Content Areas

1. Cardiovascular biology
  - Cellular mechanisms of atherosclerotic vascular disease
  - Genetics
2. Clinical epidemiology
  - Incidence and prevalence of CVD
  - Relationship between risk factors/markers and CVD outcomes
  - Gender and racial differences (1)
  - Population demographics (aging and socioeconomic status) (2)

3. Biostatistics
  - Analytical methods
  - Software for basic analyses
4. Clinical trials
  - Statistical analyses (tracking experimental data)
  - Study design (including calculation of sample size) and understanding of methodology
  - Data collection
  - Data safety and monitoring
  - Meta-analyses
5. Outcomes research
  - Medical economics
  - Cost/benefit analyses
  - Policy and legislation
6. Cardiovascular pharmacology
  - Mechanism of action
  - Safety profile
  - Efficacy and indication
7. Behavioral and psychosocial aspects of CVD (3)
  - Affective disorders (depression, anxiety)
  - Compliance
  - Behavior modification (coping)
8. Risk assessment
  - Traditional risk factors
  - Nontraditional risk factors (e.g., high-sensitivity C-reactive protein [4], apolipoprotein B, lipoprotein [a])
  - Advanced risk assessment (renal, hepatic, inflammatory, and autoimmune related)
9. Assessment of subclinical atherosclerosis
  - Coronary artery calcification (5-10)
  - Carotid intima-media thickness (11-13)
  - Ankle-brachial index (14,15)
10. Risk factor management
  - Hypertension
  - Lipids
  - Nutrition
  - Thrombosis
  - Smoking
  - Exercise
  - Pre-diabetes, insulin resistance, metabolic syndrome, and diabetes mellitus
  - Atherosclerosis reversal
11. Disease management
  - Multidisciplinary approach
  - Adherence
  - Education of primary care physicians

#### Specific Content Areas

Exposure to specific content areas in CVD prevention is essential. These specific areas, outlined in an ABC format (16,17), must encompass diagnosis and treatment in both primary and secondary prevention settings.



## A

### Antiplatelet/Anticoagulant Therapy

- Aspirin
- Clopidogrel (P<sub>2</sub>Y<sub>12</sub> receptor antagonists)
- Warfarin sodium: use in patients with atrial fibrillation and/or left ventricular thrombus

### Angiotensin Converting Enzyme Inhibitor (ACE-I)/Angiotensin Receptor Blocker (ARB) Therapy

- ACE-I
- ARB
- ACE-I and ARB combination therapy

### Antianginal/Anti-Ischemic Therapies

- Nitrates
- Beta blockers
- Calcium channel blockers
- Novel antianginals (i.e., ranolazine)

### Atherothrombosis

- Hypercoagulable states/thrombosis
- Peripheral arterial disease

## B

### Blood Pressure Control

- Familiarity with the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure guidelines (18)

### Beta-Blocker Therapy

- Antiarrhythmic, antianginal and sympatholytic effects
- Secondary prevention of CVD in patients with a myocardial infarction, heart failure/left ventricular systolic dysfunction or hypertension

## C

### Cholesterol Management

- Familiarity with National Cholesterol Education Program guidelines for low-density lipoprotein-cholesterol, high-density lipoprotein-cholesterol, and triglycerides (19)

### Cigarette Smoking Cessation

- Role of tobacco in the development and progression of CVD and as a predictor of future cardiovascular events in persons with established coronary artery disease (20)
- Familiarity with combination, long-term behavioral support and pharmacologic therapy with or without nicotine replacement for smoking cessation

## D

### Diet and Weight Management

- Diet: Familiarity with appropriate cardiovascular dietary choices and interventions for change in dietary habits

- Weight Management: Familiarity with definitions of normal, overweight, and obese states and measures to define abnormal weights (body mass index, waist:hip ratio); association of weight and increased rates of cardiovascular events, death, and development of comorbid conditions (diabetes mellitus, hypertension, hypercholesterolemia); caloric reductions and increased activity to reach ideal body weight

### Diabetes Mellitus and the Metabolic Syndrome

- Familiarity with these terms (as they relate to patients with and without CVD); guidelines for diagnosis and recommended interventions (lifestyle changes, clinical pharmacotherapy)
- Role of diabetes mellitus as a potential risk factor for CVD and accelerated rates of atherosclerosis (21)

## E

### Exercise/Cardiac Rehabilitation (22-24)

- Association of inadequate levels of exercise with risk of cardiovascular events
- Role of cardiac rehabilitation for patients with chronic stable angina pectoris, recent myocardial infarction, recent coronary artery bypass graft surgery, noncoronary heart surgery, cardiac transplant, and/or left ventricular systolic function

### Ejection Fraction

- Assessment for patients with known CVD
- Role of adjunctive therapies (aldosterone blockade, digitalis, etc.) in patients with left ventricular systolic function

Although detailed, it is important to realize that this list of key measures should not be considered all-inclusive. The field of cardiovascular prevention is ever changing, as epidemiologic and clinical trial data accumulates. Because of this, training programs should be oriented toward providing the most up-to-date guidelines for all risk factors in the primary and secondary prevention of CVD.

Level 1 training in these areas should ideally be undertaken in a 1-month (or longer) rotation dedicated to preventive cardiovascular medicine (Table 1). An acceptable alternative would be a 3-month (or longer) clinical cardiology rotation that allows concomitant exposure to a comprehensive cardiovascular rehabilitation program at least 1 day each week. This would allow incorporation of a broad range of preventive approaches in addition to the predominant rehabilitation focus of physical exercise (11). Ideally, the 1-month rotation should include weekly attendance at a cardiac rehabilitation program, a diabetes mellitus or endocrinology clinic, and a lipid disorders clinic.

As an alternative, training in these areas could be obtained in consultative, inpatient, and outpatient rotations, with additional didactic sessions focusing on cardiovascular prevention topics. If the latter approach is taken, the time

**Table 1** Summary of Training Requirements for Preventive Cardiovascular Medicine

Level	Duration of Training (Months)	Cumulative Duration of Training (Months)	Types of Training Experiences
1	1	1	Genetics of CVD, risk prediction, clinical epidemiology, biostatistics, clinical trials, outcomes research, clinical pharmacology, behavior modification, and disease management.
2	6 to 12	6 to 12	Blocks of time devoted to study of patients with advanced atherosclerosis, hypertension, hyperlipidemia, recurrent thrombosis, cardiac rehabilitation, or related subspecialty work.
3	12	12	In-depth study of one of the above areas.

CVD = cardiovascular disease.

allotted should be equivalent to at least 1 month of full-time training. Training program directors may also consider supplementing clinical experiences with short courses devoted exclusively to preventive cardiovascular medicine or risk factor evaluation and management.

### Level 2

Level 2 training should achieve a level of expertise such that the trainee could serve as an independent consultant to other cardiovascular practitioners in the management of cardiovascular risk factors. This should involve 6 to 12 months of training within the 36 months of a cardiovascular training program and should include time for direct evaluation of patients with advanced atherosclerosis, hypertension, hyperlipidemia, recurrent thrombosis, cardiac rehabilitation, or related subspecialty conditions.

Level 2 training should involve blocks of time spent in hypertension, lipid, and diabetes clinics or services, peripheral vascular laboratories, and clinical and cardiac rehabilitation services with additional exposure to behavioral medicine, exercise physiology, clinical epidemiology, outcomes research, and vascular biology. To achieve training at Level 2, aggregate training in preventive laboratories and services should account for a minimum of 6 months of a typical 3-year training program in cardiovascular medicine.

### Level 3

Level 3 requires advanced training to qualify as director of a clinical service, research program, or both. Examples include the director of a preventive cardiovascular medicine, hypertension or lipid service; director of a cardiac rehabilitation program, director of a vascular medicine laboratory; or a trainee who obtains an MPH degree in clinical epidemiology, outcomes research, or both.

Training at this level would require 1 year of a 36-month training program. This level of experience may require additional formal education and training beyond a basic 3-year program. Alternatively, 2 to 3 years in a vascular biology laboratory or health services outcomes research/clinical epidemiology program would be required to attain expertise in these fields which would possibly lead to achievement of an advanced degree.

The most effective preventive cardiovascular medicine services incorporate the skills and knowledge of multiple

providers, including cardiovascular physicians, nurses, nurse practitioners, physician assistants, dietitians, behavioral medicine specialists, and exercise physiologists. They operate on principles of interdisciplinary and multidisciplinary teamwork, and they use systemic approaches to patient care. Although such programs are more effective than routine cardiovascular practice, few training programs offer opportunities to learn these new skills. Programs interested in offering Level 3 training should incorporate these new concepts into the training program and trainees interested in Level 3 training should seek programs that offer these advanced approaches to patient care.

## Evaluation

Whereas knowledge of preventive interventions and mechanisms has blossomed in the past 10 years, clinical practice in this area lags behind in virtually all practice settings. Even academic centers, where most trainees are taught, fail to provide ideal preventive services to cardiovascular patients. Evaluation of the training in preventive cardiovascular medicine could logically include efforts by clinical programs to evaluate their own clinical inputs and outcomes and demonstrate commitment to ongoing quality improvement in clinical prevention. Programs could also use the Adult Clinical Cardiology Self-Assessment Program (ACCSAP) education programs and examinations to ensure trainees (and faculty) have acquired appropriate knowledge of preventive cardiovascular medicine.

*This is a revision of the 2002 document that was written by Phillip Greenland, MD, FACC—Chair; Edward D. Frohlich, MD, FACC; C. Noel Bairey Merz, MD, FACC; and Richard C. Pasternak, MD, FACC. We are especially indebted to the valuable comments and suggestions by M. Dominique Ashen, PhD, CRNP, and Matthew J. Budoff, MD.*

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**Key Words:** ACCF Training Statement ■ COCATS 3 ■ preventive cardiovascular medicine ■ cardiovascular disease.

## APPENDIX 1. AUTHOR RELATIONSHIPS WITH INDUSTRY—ACCF 2008 RECOMMENDATIONS FOR TRAINING IN ADULT CARDIOVASCULAR MEDICINE CORE CARDIOLOGY TRAINING (COCATS 3)—TASK FORCE 10: TRAINING IN PREVENTIVE CARDIOVASCULAR MEDICINE

Name	Consultant	Research Grant	Scientific Advisory Board	Speakers' Bureau	Steering Committee	Stock Holder	Other
Dr. Vera A. Bittner	None	None	None	None	None	None	None
Dr. Roger S. Blumenthal	None	<ul style="list-style-type: none"> <li>• AstraZeneca</li> <li>• Kos Pharmaceuticals</li> <li>• Merck</li> <li>• Pfizer</li> <li>• Sanofi-Aventis</li> <li>• Schering-Plough</li> </ul>	None	<ul style="list-style-type: none"> <li>• AstraZeneca</li> <li>• Kos Pharmaceuticals</li> <li>• Merck</li> <li>• Pfizer</li> <li>• Sanofi-Aventis</li> <li>• Schering-Plough</li> </ul>	None	None	None
Dr. Tyler J. Gluckman	None	None	None	None	None	None	None
Dr. C. Noel Bairey Merz	• Bayer	None	None	None	None	None	Stock owned— <ul style="list-style-type: none"> <li>• Boston Scientific</li> <li>• Eli Lilly</li> <li>• Medtronic</li> <li>• Johnson &amp; Johnson</li> </ul>

This table represents the relationships of committee members with industry that were reported by the authors as relevant to this topic. It does not necessarily reflect relationships with industry at the time of publication.

## APPENDIX 2. PEER REVIEWER RELATIONSHIPS WITH INDUSTRY—ACCF 2008 RECOMMENDATIONS FOR TRAINING IN ADULT CARDIOVASCULAR MEDICINE CORE CARDIOLOGY TRAINING (COCATS 3)—TASK FORCE 10: TRAINING IN PREVENTIVE CARDIOVASCULAR MEDICINE

Name*	Affiliation	Consultant	Research Grant	Scientific Advisory Board	Speakers' Bureau	Steering Committee	Stock Holder	Other
Dr. Rick A. Nishimura	• Official–Board of Trustees	None	None	None	None	None	None	None
Dr. Gregg C. Fonarow	• Content–Prevention Committee	<ul style="list-style-type: none"> <li>• AstraZeneca</li> <li>• Bristol Myers-Squibb</li> <li>• GlaxoSmithKline</li> <li>• Guidant</li> <li>• Merck</li> <li>• Medtronic</li> <li>• Nitromed</li> <li>• St. Jude Medical Center</li> <li>• Pfizer</li> <li>• Sanofi-Aventis</li> <li>• Scios</li> </ul>	<ul style="list-style-type: none"> <li>• GlaxoSmithKline</li> <li>• Medtronic</li> </ul>	None	None	None	None	None
Dr. Alan D. Forker	• Content–Prevention Committee	None	<ul style="list-style-type: none"> <li>• GlaxoSmithKline</li> <li>• Merck</li> <li>• Novartis</li> <li>• Pfizer</li> <li>• Reliant</li> <li>• Sankyo</li> <li>• Sanofi-Aventis</li> <li>• Takeda</li> </ul>	None	<ul style="list-style-type: none"> <li>• Medcom: Coach</li> <li>• Medcom: Vascular Biology Working Group</li> <li>• Merck</li> <li>• Novartis</li> <li>• Pfizer</li> <li>• Takeda</li> </ul>	None	None	None
Dr. Rita F. Redberg	• Content–Prevention Committee	None	None	• CV Therapeutics	None	None	None	None

This table represents the relationships of peer reviewers with industry that were reported by the authors as relevant to this topic. It does not necessarily reflect relationships with industry at the time of publication. \*Names are listed in alphabetical order with each category of review.

## Task Force 11: Training in Vascular Medicine and Peripheral Vascular Catheter-Based Interventions

*Endorsed by the Society for Cardiovascular Angiography and Interventions and the Society for Vascular Medicine*

Mark A. Creager, MD, FACC, *Chair*

John P. Cooke, MD, PhD, FACC, Jeffrey W. Olin, DO, FACC (*Society for Vascular Medicine Representative*), Christopher J. White, MD, FACC

Cardiovascular physicians frequently encounter vascular diseases. Atherosclerosis and thrombosis, in particular, are systemic disorders with clinical manifestations in most peripheral circulations. These and other vascular diseases account for substantial cardiovascular morbidity and mortality. Moreover, technological advances in imaging techniques and catheter-based interventions have brought management of vascular diseases firmly into the sphere of the cardiovascular specialist. Training in vascular medicine should be incorporated in a cardiovascular fellowship in

order to accommodate the clinical demands of this contemporary paradigm. Accordingly, 3 levels of training in vascular medicine are described.

**Level 1**—Basic training in vascular medicine that all fellows should receive to acquire a sufficient knowledge base to care for many patients with vascular disease.

**Level 2**—Additional training for fellows who wish to develop special expertise in evaluating and managing patients with vascular disease. This level does not include training in catheter-based interventions.



**Level 3**—Training for noncoronary peripheral vascular catheter-based vascular interventions. This level of training is to ensure that the fellow develops both the cognitive and technical skills requisite to making appropriate decisions regarding invasive and interventional treatment of patients with vascular disease.

### Level 1: Basic Training for All Cardiovascular Fellows

The essentials of vascular medicine should be taught to all fellows. Vascular medicine training should be integrated into the fellowship program and include the evaluation and management of vascular diseases, exposure to noninvasive diagnostic modalities, angiography, and peripheral catheter-based interventions. The equivalent of at least 2 months of the fellowship, either as dedicated rotations or in the aggregate as an integral component of other rotations, should be devoted to vascular medicine. Acquisition of this fundamental knowledge will permit the fellow to recognize a broad array of vascular diseases and common medical disorders associated with vascular disease, to initiate appropriate medical management, and to appropriately refer patients to a vascular specialist when necessary for further evaluation and intervention. This level of training, however, is not sufficient to qualify the trainee as a vascular specialist capable of managing complex vascular patients.

#### Components of Training

The fellow should receive training in the evaluation and management of arterial, venous, and lymphatic diseases, such as peripheral arterial disease, acute arterial occlusion, carotid artery disease, renal artery stenosis, aortic aneurysm, vasculitis, vasospasm, venous thrombosis and insufficiency,

and lymphedema (Table 1). Training should also include instruction in the recognition and management of medical disorders associated with vascular diseases, including hypertension, hypercholesterolemia, diabetes mellitus, and hypercoagulable states. Fellows should also be trained to perform a comprehensive pre-operative evaluation of the patient undergoing vascular surgery, to be cognizant of the indications and risks of pre-operative testing, and to manage cardiovascular problems in the perioperative period.

Trainees should receive instruction in the noninvasive vascular laboratory and know the indications for vascular tests, such as segmental pressure measurements, pulse-volume recordings, and duplex ultrasonography, as well as the information that can be derived from such testing. Furthermore, the fellow should understand the imaging techniques that can be used to further assess the aorta, vena cavae, and peripheral arteries and veins, such as computed tomography angiography (CTA) and magnetic resonance angiography (MRA), and recognize the indications for catheter-based interventions and surgical revascularization.

All cardiovascular medicine fellowship candidates should participate in noncardiac peripheral angiography (i.e., aortography; angiography of first-order branch vessels of the aorta, such as the iliac, renal, or subclavian arteries; and second-order branch vessels, such as the internal mammary arteries; and pulmonary angiography) in patients with whom they are involved from pre-catheterization clinical evaluation to final disposition. This training will not qualify the trainee to independently perform peripheral angiography.

#### Structure of the Level 1 Training Program

##### Faculty

In a few institutions, leadership for the vascular medicine component of the training program will come from vascular

**Table 1** Summary of Training Requirements for Vascular Medicine and Peripheral Catheter-Based Interventions

Level	Duration of Training (Months)	Components of Training	Cumulative Number of Procedures*
1	2	Evaluation and management of arterial, venous, and lymphatic disease, atherosclerotic risk factors, and hypercoagulable states Noninvasive vascular laboratory and vascular imaging (i.e., ultrasound, MRA, CTA)	
2 (vascular medicine specialist)†	12	Outpatient vascular medicine clinic Inpatient vascular medicine consultation service Noninvasive vascular laboratory, examinations MRA/CTA Peripheral vascular catheterization Vascular surgery	<u>Noninvasive vascular lab</u> 100 venous ultrasounds 100 carotid artery ultrasounds 100 limb artery ultrasounds 75 renal/mesenteric vascular ultrasounds 100 physiologic arterial examinations
3 (peripheral vascular intervention)‡	12	Outpatient vascular medicine clinic Inpatient medical consultation service Vascular imaging, including ultrasound, MRA, CTA (1 to 2 months) Peripheral vascular catheterization and intervention	<u>Peripheral vascular interventions</u> 100 diagnostic peripheral angiograms 50 peripheral angioplasties/tents 10 peripheral thrombolytic infusions/thrombectomy

\*These are estimates based on the most recently published guidelines and will be kept current as guidelines are updated. After completing Level 1, trainees can elect to pursue Level 2 training, Level 3 training, or both, emphasizing either the medical evaluation and management of the vascular patient and the noninvasive vascular laboratory (Level 2) or peripheral vascular catheter-based interventions (Level 3). Level 2 training is not a prerequisite for Level 3 training but is intended for individuals who want to become a vascular medicine specialist. †The prerequisite for Level 2 training is Level 1 training in vascular medicine. ‡The prerequisite for Level 3 training includes Level 1 training in vascular medicine, and Level 1 and Level 2 training in diagnostic cardiac catheterization. Requirements for Level 3 training in peripheral vascular intervention can be fulfilled during a fourth year of interventional training focused on peripheral vascular intervention or concurrently with cardiac interventional training.

CTA = computed tomography angiography; MRA = magnetic resonance angiography.

medicine specialists. In many programs, however, the exposure to vascular medicine will come from faculty in other disciplines, such as cardiology, hematology, neurology, vascular surgery, and vascular radiology. All faculty responsible for training fellows in vascular medicine should be board certified or board eligible and recognized as experts in their subspecialties.

### Facilities

The principal training institution should have facilities to care for patients with vascular disease that include a noninvasive vascular laboratory accredited by the Intersocietal Commission for the Accreditation of Vascular Laboratories (ICAVL), a peripheral vascular catheterization laboratory, a comprehensive vascular surgery program, and offices for outpatient evaluation and treatment.

### Content of Conferences

Conferences should incorporate case presentations and formal lectures that review current diagnostic and therapeutic approaches to arterial, venous, and lymphatic disease. Case presentations should illustrate the use of clinical tools, noninvasive laboratory testing, and angiography. Conferences should provide the trainee with information regarding the natural history of peripheral vascular disorders, the long-term risks and benefits of peripheral intervention, and noninterventional approaches to vascular disease. Formal lectures on the pathobiology of vascular diseases, including atherosclerosis, restenosis, and thrombosis, should be incorporated.

### Trainee Evaluation

The fund of knowledge regarding vascular disease must be evaluated in every trainee. Quality of clinical skills; reliability; judgments or actions that result in patient complications; and interaction with other physicians, patients, and laboratory support staff are key components of the evaluation. Initiative and ability to make independent and appropriate decisions are to be considered. The program director has the responsibility to confirm or deny the experience and competence of trainees.

## Level 2: Requirements for Training Fellows Wishing to Pursue a Career in Vascular Medicine

Fellows planning a career in vascular medicine require a distinct and comprehensive training program. In addition to the 24 months required for board eligibility in cardiovascular medicine, another 12 months of training, typically during a third or fourth year, should provide a curriculum to enable the fellow to become an expert in vascular medicine (1,2). The prerequisite for Level 2 training is Level 1 training in vascular medicine. The fellow who wishes to be trained in peripheral vascular intervention will require additional training as outlined in later text (see Level 3).

## Components of Training

Trainees who plan a vascular medicine track as part of their cardiovascular fellowship should spend at least 2 to 3 months on an inpatient vascular medicine consultation service; 3 months in the noninvasive vascular laboratory; 1 to 2 months learning MRA and CTA; and 1 to 2 months in the peripheral vascular catheterization laboratory (Table 1). In addition, at least one-half to 1 day per week throughout the year should be spent in the outpatient vascular medicine clinic. In addition, there should be sufficient exposure to the diagnosis and treatment of peripheral arterial disease, aortic diseases, cerebrovascular disease, renal artery stenosis, venous thromboembolic diseases, chronic venous disorders, lymphatic diseases, vasculitides, atheromatous embolization, vasospastic disease, and chronic venous insufficiency, as well as other uncommon vascular diseases.

The time spent on the inpatient hospital service and outpatient clinic should include experience with risk factor modification, including smoking cessation interventions and treatment of dyslipidemia, hypertension, and thrombophilic disorders, because these are important components of many vascular diseases. Additional rotations could be allocated to vascular surgery, hematology, neurology, and rheumatology to acquire fundamental experience in these important areas as they relate to vascular medicine.

Expertise in the noninvasive vascular laboratory is one of the most important aspects of training for the vascular medicine specialist. Although the principles of ultrasound are the same whether one is performing an echocardiogram or a vascular ultrasound, there are many important differences in technique and interpretation that require special training. The trainee should understand the principles of ultrasound physics, Doppler characteristics, and transducer technology. The fellow should perform and interpret the following vascular studies under supervision: 1) duplex ultrasonography of the veins and arteries of the upper and lower extremities; 2) the aorta; 3) the renal and mesenteric arteries and veins; 4) the carotid arteries; 5) infrainguinal bypass grafts; and 6) physiologic tests of peripheral arteries and veins, among others. The number of noninvasive vascular laboratory procedures required for each of the studies performed in the vascular laboratory should follow the guidelines recommended by the ICAVL (3). These include, but are not limited to, 100 venous, 100 peripheral artery (including bypass grafts), 100 carotid artery, and 75 visceral artery and venous (renal and mesenteric) duplex ultrasound studies, as well as 100 physiologic arterial examinations.

In addition, dedicated time should be spent learning the basic principles of MRA and CTA. The trainees should acquire the cognitive and clinical skills necessary to review the MRA and CTA of peripheral vessels, including the aorta, and brachiocephalic, limb, renal, and mesenteric arteries when evaluating patients with vascular disease. This experience is not intended to qualify the trainee in the

performance and formal interpretation of MRA or CTA. Expertise in MRA and CTA will require additional time to acquire the comprehensive skills needed to perform and independently interpret these imaging modalities (see the Task Force 12 and 13 reports).

During the period of training in the catheterization laboratory, the fellow should learn the fundamentals of angiography and peripheral catheter-based interventions. The trainee should participate in peripheral diagnostic angiograms and peripheral interventions, including angioplasty, stent implantation, and thrombolysis. Training should emphasize interpretation of angiograms and permit the fellow to acquire an understanding of the indications and potential outcomes of invasive diagnostic procedures and catheter-based treatments. This experience is not intended to qualify the trainee as an interventionalist (see Level 3).

### Structure of the Level 2 Training Program

#### Faculty

The trainee should be exposed to individuals who have special training in vascular medicine and cardiovascular diseases. Ideally, these faculty will be board certified in vascular medicine and/or endovascular medicine by the American Board of Vascular Medicine. It is recognized, however, that this may not be possible at all institutions. Therefore, the cardiovascular fellow may need to spend time in other departments or divisions to gain the necessary expertise to be a vascular medicine specialist. As per Level 1 training, all faculty responsible for training fellows in vascular medicine should be board certified or board eligible and recognized as experts in their subspecialties. Areas where this may be most important include the noninvasive vascular laboratory, angiography suite, vascular surgery, hematology, neurology, and rheumatology. The faculty should be required to provide didactic and practical education to the fellow, as well as appropriate feedback about the trainee's performance.

#### Facilities

Adequate space should be available in the outpatient clinics to see patients. The noninvasive vascular laboratory should be accredited by the ICAVL and have equipment of suitable quality to perform all of the studies previously listed. There should be dedicated, fully equipped areas for magnetic resonance and computed tomographic imaging. A peripheral vascular catheterization laboratory equipped as stated in the following text should also be a requirement for the cardiovascular fellow's training in vascular medicine. There should be an active and comprehensive vascular surgery program at the institution, and facilities for treatment of leg ulcers should be available.

#### Content of Conferences

The cardiovascular fellowship program should have a comprehensive conference series for topics of importance for the

vascular medicine specialist. A conference dedicated to a core curriculum of topics should be scheduled throughout the year. Additional conferences could include angiography and imaging, vascular medicine grand rounds, a journal club, and morbidity and mortality.

#### Evaluation of Trainee and Faculty

As with every successful post-graduate training program, this program requires bi-directional evaluations. The faculty evaluates and provides positive and negative feedback to the trainee, and the trainee evaluates the faculty. Formal evaluations of the fellows and faculty should occur after each rotation. The program director should review these evaluations with the trainee and with the faculty individually. Mechanisms should be incorporated into the training program so that the fellow who performs suboptimally can be counseled and further action can be taken if necessary. The American Board of Vascular Medicine administers a certifying examination in vascular medicine. The fellow will be expected to take and pass this examination.

### Level 3: Training for Peripheral Vascular Catheterization and Intervention

Catheter-based peripheral angiography (arterial and venous) and interventional procedures are important components of a modern clinical cardiovascular practice. The trainee who plans to perform peripheral catheter-based angiography and interventions will be required to complete an additional period of training in these special procedures to obtain the basic fund of knowledge, technical skills, and the clinical judgment requisite for performing these invasive studies (1).

#### Components of Training

Trainees who plan to perform independent peripheral vascular catheterization (arteriography and venography) and interventions must become knowledgeable about normal vascular anatomy and common anatomic variants and become familiar with the common patterns of collateral formation. They must learn the theoretical and practical aspects of radiation physics and safety. A working knowledge of the cardiovascular angiographic laboratory equipment, including physiologic recorders, pressure transducers, blood gas analyzers, image intensifiers, cine processing, digital imaging, and image archiving, is required. An understanding of the fundamental principles of pressure waveform recording and analysis is mandatory.

Trainees should receive specific training in the techniques of vascular access from multiple sites (femoral, popliteal, and upper extremity arteries and veins). They should be trained to manipulate guidewires and catheters, place and deploy angioplasty equipment and devices, perform catheter-directed thrombolysis/thrombectomy, and obtain hemostasis via the application of compression and vascular closure devices. They should acquire the ability to perform vascular



interventions in each of the following: aorta and lower extremity arteries, cervical arteries, brachiocephalic and upper extremity arteries, mesenteric and renal arteries, central and peripheral veins, and pulmonary arteries. Trainees must learn the indications, limitations, and complications of vascular interventional procedures, and understand the alternative treatments.

Level 3 training in peripheral angiography and catheter-based peripheral vascular intervention must also provide the fellow with the cognitive tools requisite to evaluating and managing patients with vascular disease. In some respects, this overlaps with Level 2 training. Trainees should spend the equivalent of 1 month on an inpatient vascular consultation service, 1 to 2 months dedicated to vascular imaging (including duplex ultrasonography, and MRA and CTA), and 1 half-day per week in an outpatient vascular clinic to acquire the knowledge necessary to manage patients with peripheral arterial disease, aortic diseases, renal artery stenosis, cerebrovascular disease, venous thrombosis, and other relevant vascular diseases (Table 1). The trainees should acquire the cognitive and clinical skills necessary to review duplex ultrasound studies of peripheral arteries and veins as well as the MRA and the CTA of peripheral vessels, including the aorta, and brachiocephalic, limb, renal, and mesenteric arteries when evaluating patients with vascular disease as described for Level 2 training. This experience is not intended to qualify the trainee in the performance and formal interpretation of vascular ultrasound studies, MRA, or CTA. Level 2 training is not a prerequisite for Level 3 training but is suggested for those wishing to acquire comprehensive training in vascular medicine in order to complement skills developed during Level 3 training.

### Structure of the Level 3 Training Program

#### Faculty

The training program must have a director of the catheterization laboratory who has primary responsibility for administration and teaching. The program director must be board certified in interventional cardiology or have equivalent credentials. More than 1 faculty member is required to participate in the peripheral interventional training of the fellows. All faculty responsible for training fellows in catheter-based peripheral angiography and intervention should be board certified or board eligible by the American Board of Internal Medicine (ABIM) Subspecialty Board on Cardiovascular Disease and recognized by his or her peers as an expert in peripheral catheter-related intervention. Ideally, faculty should have received additional certification in cardiovascular intervention by the ABIM Subspecialty Board on Cardiovascular Disease or passed the American Board of Vascular Medicine Endovascular Examination.

#### Facilities

A fully equipped and staffed angiographic and hemodynamic laboratory dedicated to cardiovascular procedures is

required. All training facilities must be equipped and staffed and function in accordance with the most recent American College of Cardiology (ACC) recommendations for peripheral transluminal angioplasty, training, and facilities. Peripheral vascular surgery must be performed in the training institution to support catheter-based interventions.

#### Patients

All trainees should be exposed to adult patients with vascular diseases as outlined in the previous text. These include patients with peripheral arterial disease, aortic diseases, cerebrovascular disease, renal artery stenosis, venous thromboembolic diseases, vasculitides, atheromatous embolization, and uncommon vascular diseases.

The trainee planning a career in angiography and catheter-based vascular interventions must be trained to perform procedures in acutely and chronically ill patients, including emergency patients with acute limb ischemia.

#### Duration of Training

For the cardiovascular trainee who plans to independently perform peripheral angiography and catheter-based peripheral vascular interventions, Level 1 training in vascular medicine, and Level 1 and Level 2 training in the cardiac catheterization laboratory are required as a prerequisite (also see the Task Force 3 report). Requirements for Level 3 training in peripheral vascular intervention can be fulfilled during a fourth year of interventional training focused on peripheral vascular intervention or concurrently with cardiac interventional training.

For trainees planning to perform peripheral vascular interventional procedures, dedicated peripheral vascular interventional fellowship training is required, during which time the minimum requirements specified by the Clinical Competence Statement on Vascular Medicine and Catheter-Based Peripheral Vascular Interventions must be met (1). These requirements can be met during a fourth year of interventional training focused on peripheral vascular intervention or concurrently with cardiac interventional training. Current guidelines for competence indicate that trainees should perform at least 100 diagnostic angiograms, 50 peripheral angioplasties, and 10 peripheral thrombolytic/thrombectomy interventions.

#### Content of Conferences

All trainees must attend a regular cardiovascular catheterization and angiography conference. It is important that the cardiologist understand the complexities and limitations of the cardiovascular angiographic laboratory. Formal conferences should stress the relation of medical history, physical examination findings, hemodynamic findings, and angiographic findings for the selection of patients for therapy (i.e., medicine, surgery, or intervention). Interaction with the other vascular specialists at these conferences is important.

The trainee should be familiar with the rationale for patient selection for these diagnostic studies and should be required to



attend conferences at least weekly for the duration of the catheterization/angiography rotation. Attendance at regular morbidity and mortality conferences is a requirement.

### Trainee Evaluation

Case selection and procedural judgment, as well as interpretive and technical skills, must be evaluated in every trainee. This is particularly important for the trainee who eventually will work full time in a diagnostic cardiovascular angiography laboratory or perform catheter-based vascular interventional procedures. Quality of the clinical follow-up; reliability; judgments or actions that result in patient complications; interaction with other physicians, patients, and laboratory support staff; appropriate initiative; and the ability to make independent and appropriate decisions should be considered.

The competence of all cardiology trainees in cardiovascular angiography and intervention should be documented by both the program director and the director of the catheterization laboratory. The program director has the responsibility to confirm or deny the technical competence and catheterization laboratory exposure of trainees. The granting of hospital privileges remains within the purview of the individual institution.

Evaluation of the trainee who undertakes special training in catheter-based peripheral angiography and vascular intervention shall include the documentation (in the form of a logbook containing clinical information, procedure performed, and outcome of the procedure, including any complications experienced by the patient) of the perfor-

mance of at least the minimum number of procedures set forth in the Clinical Competence Statement on Vascular Medicine and Catheter-Based Peripheral Vascular Interventions (1). Evaluation of the trainee for catheter-based peripheral vascular intervention shall include the documentation (in the form of a logbook) of the performance of at least the minimum number of procedures set forth in the Clinical Competence Statement (1).

*This is an update of the 2002 document that was written by Mark A. Creager, MD, FACC—Chair; John P. Cooke, MD, PhD, FACC; Jeffrey W. Olin, DO, FACC (Society of Vascular Medicine and Biology Representative); and Christopher J. White, MD, FACC.*

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**Key Words:** ACCF Training Statement ■ COCATS 3 ■ vascular medicine ■ peripheral vascular catheter-based intervention ■ computed tomography angiography ■ peripheral vascular intervention.

## APPENDIX 1. AUTHOR RELATIONSHIPS WITH INDUSTRY—ACCF 2008 RECOMMENDATIONS FOR TRAINING IN ADULT CARDIOVASCULAR MEDICINE CORE CARDIOLOGY TRAINING (COCATS 3)—TASK FORCE 11: TRAINING IN VASCULAR MEDICINE AND PERIPHERAL VASCULAR CATHETER-BASED INTERVENTIONS

Name	Consultant	Research Grant	Scientific Advisory Board	Speakers' Bureau	Steering Committee	Stock Holder	Other
Dr. John P. Cooke	• Athenagen	• Genzyme	None	• Bristol-Myers Squibb	None	• Athenagen • Lumen	None
Dr. Mark A. Creager	None	• Bristol-Myers Squibb • Sanofi-Aventis U.S. Partnership	• Biomarin	• Bristol-Myers Squibb • Sanofi-Aventis U.S. Partnership	• Bristol-Myers Squibb • Genzyme • Sanofi-Aventis U.S. Partnership • Sigma Tau, Vasogen	None	None
Dr. Jeffrey W. Olin	• Bristol-Myers Squibb • Genzyme • Sanofi	• Bristol-Myers Squibb • Genzyme • Sanofi • Vasogen	• Bristol-Myers Squibb • Sanofi	None	• Genzyme • Vasogen	None	None
Dr. Christopher J. White	None	None	None	None	None	None	None

This table represents the relationships of committee members with industry that were reported by the authors as relevant to this topic. It does not necessarily reflect relationships with industry at the time of publication.

**APPENDIX 2. PEER REVIEWER RELATIONSHIPS WITH INDUSTRY—ACCF 2008 RECOMMENDATIONS FOR TRAINING IN ADULT CARDIOVASCULAR MEDICINE CORE CARDIOLOGY TRAINING (COCATS 3)—TASK FORCE 11: TRAINING IN VASCULAR MEDICINE AND PERIPHERAL VASCULAR CATHETER-BASED INTERVENTIONS**

Name*	Affiliation	Consultant	Research Grant	Scientific Advisory Board	Speakers' Bureau	Steering Committee	Stock Holder	Other
Dr. Rick A. Nishimura	• Official—Board of Trustees	None	None	None	None	None	None	None
Dr. Jeffrey J. Cavendish	• Official—Board of Governors	None	None	None	None	None	None	None
Dr. Matthew R. Wolff	• Official—Board of Governors	None	None	None	None	None	None	None
Dr. John E. Brush, Jr.	• Content—Individual Reviewer	None	None	None	None	None	None	None
Dr. Marie D. Gerhard-Herman	• Content—Peripheral Vascular Disease Committee	None	None	None	None	None	None	None
Ms. Cathy Pensyl	• Content—Peripheral Vascular Disease Committee	None	None	None	None	None	None	None
Dr. Kenneth Rosenfield	• Content—Peripheral Vascular Disease Committee	<ul style="list-style-type: none"> <li>• Abbott Vascular</li> <li>• Cordis</li> <li>• Endotex</li> <li>• Ev3</li> <li>• Medical Simulation</li> <li>• The Medicines Co.</li> <li>• Xtent</li> </ul>	<ul style="list-style-type: none"> <li>• Abbott Vascular</li> <li>• Bard</li> <li>• Boston Scientific</li> <li>• Cordis</li> </ul>	None	<ul style="list-style-type: none"> <li>• Boston Scientific</li> </ul>	None	<ul style="list-style-type: none"> <li>• Medical Simulation</li> <li>• Xtent</li> </ul>	None

This table represents the relationships of peer reviewers with industry that were reported by the authors as relevant to this topic. It does not necessarily reflect relationships with industry at the time of publication. \*Names are listed in alphabetical order with each category of review.

## Task Force 12: Training in Advanced Cardiovascular Imaging (Cardiovascular Magnetic Resonance [CMR])

*Endorsed by the Society for Cardiovascular Magnetic Resonance*

Gerald M. Pohost, MD, FACC, *Chair*

Raymond J. Kim, MD, FACC, Christopher M. Kramer, MD, FACC,

Warren J. Manning, MD, FACC (*Society for Cardiovascular Magnetic Resonance Representative*)

Cardiovascular magnetic resonance (CMR) (Table 1), one of the newest cardiovascular imaging modalities, provides useful, often unique information with which all cardiologists should be conversant. Accordingly, cardiovascular trainees should receive training that would provide at least a basic understanding of the methods and utility of CMR in the practice of cardiology. To accomplish such an understanding for fellows with different levels of interest in CMR, training in CMR should be provided at 3 levels—general, specialized, and advanced.

### Training Levels

**Level 1**—General training (1 month) should provide the cardiovascular trainee with a working knowledge of CMR methods and their diagnostic utility.

**Level 2**—Specialized training (at least 3 months) designed to provide the trainee in cardiovascular diseases with the skills necessary to independently interpret CMR imaging studies.

**Table 1** Classification of CMR Procedures

1. Standard CMR procedures, including:
  - a. Tomographic still-frame CMR for morphology using "bright" and/or "dark blood" methods with and/or without a paramagnetic contrast agent
  - b. Cine and other approaches to CMR for assessment of ventricular function
  - c. Magnetic resonance angiography and cine CMR of the great vessels, anomalous coronary arteries, and coronary artery bypass grafts
  - d. Delayed contrast-enhanced CMR for myocardial infarction, scar, intraventricular thrombus, and microvascular obstruction (associated with myocardial infarction) and viability assessment and visualization of other causes of abnormal myocardial interstitium
  - e. First-pass CMR (with vasodilator infusion) or cine CMR with stress (with inotropic agent) for myocardial perfusion evaluation, ischemia detection, and assessment of patients with coronary microvascular disease
  - f. Phase-contrast velocity mapping for blood flow quantification for shunt sizing and determination of valvular regurgitation and stenosis
  - g. Peripheral magnetic resonance angiography
2. Less common procedures, including:
  - a. Myocardial tagging (approach unique to CMR that allows more detailed evaluation of intramural and transmural myocardial function than ventriculography alone and for evaluation of pericardial disease)
  - b. Coronary magnetic resonance imaging of the native coronary arteries
  - c. Magnetic resonance spectroscopy using <sup>31</sup>P (to assess "high energy phosphate metabolism") or other nuclei

CMR = cardiovascular magnetic resonance.

**Level 3**—Advanced training is provided for those who ultimately wish to be responsible for the operation of a CMR laboratory. Level 3 criteria must include adequate levels of patient care, teaching, and research.

## Overview of CMR Training

All cardiovascular medicine trainees should be taught the basic types of CMR studies and their indications. Mentored interpretation of CMR studies should be coupled with comparison and integration of results with other relevant clinical and laboratory testing. A mentor is an individual with the equivalent of Level 3 CMR training. This training generally should be acquired through the Accreditation Council for Graduate Medical Education (ACGME)—an approved cardiology or radiology program with expertise in CMR and under the aegis of a Level 3-qualified mentor in a laboratory accredited by an organization such as the Intersocietal Commission on the Accreditation of MR Laboratories (ICAMRL). Occasionally, a Level 3-qualified mentor will not be available in the institution housing the general fellowship program, but is available at a nearby nonacademic medical center accredited for CMR by an organization such as the ICAMRL. Under these circumstances it is acceptable to provide the training in CMR at such a medical center for

all levels of training. The CMR training center and the trainee should maintain a logbook or other specific records to document the cases reviewed and the didactic hours in which the trainee has participated.

The depth of knowledge should increase with increasing levels of training. In the case of the Level 3 trainee, specialized training and, for academic trainees, research training related to CMR should be offered as a part of an established training program (Table 2).

## Level 1: General Training (1 Month Minimum)

The trainee should have exposure to the methods and the multiple applications of CMR for a period of not less than 1 month or its equivalent when integrated with other training activities. This experience should provide basic background knowledge in CMR sufficient for the practice of adult cardiology and referral for CMR evaluation, but not for the practice or independent clinical interpretation of CMR. As a practical matter, many fellowship programs in cardiovascular medicine may not be able to fulfill CMR training. In these instances, fellows should be encouraged to obtain experience in an alternate program with appropriate training and accreditation in the performance of CMR studies.

**Table 2** Components of CMR Training

1. Didactic activities
  - a. Lectures (It will be necessary in learning the physical principles and in case interpretation to derive such information from relevant lectures; no more than 5% of the cases.)
  - b. Self-study (it is possible to use cases from teaching files, journals, textbooks, or electronic/on-line courses. Such self-study cases need to be well documented in the trainee's records and should not comprise any more than 50% of the cases studied.)
2. Independent interpretation of CMR cases (performed in the mentoring CMR laboratory)
3. Participation in CMR case study interpretation
4. "Hands-on" CMR experience

CMR = cardiovascular magnetic resonance.

## Didactic Activities

**Interpretation of CMR studies.** During his or her 1 month of training, the trainee should actively participate in daily CMR study interpretation under the direction of a Level 2- or Level 3-trained CMR physician-mentor. For all studies in which angiographic, echocardiographic, radionuclide, computed tomographic, or hemodynamic data are available, this other imaging information should be correlated with CMR studies. Studies should include the range of procedures listed in Table 1. Experience in interpretation (a minimum of 25 cases) may include studies from an established CMR teaching file.

**Lectures and self-study in CMR.** This component should consist of lectures on the basic aspects of CMR and parallel reading material consisting of selected articles, digital training programs, or CMR text. The lectures and reading should provide the fellow with an understanding of CMR applications. Specificity, sensitivity, diagnostic accuracy, utility in assessing prognosis, costs, artifacts, indications, contraindications, and pitfalls must be included for each cardiovascular diagnostic subset. Such information could be effectively transmitted within a weekly noninvasive or clinical teaching conference during which CMR data are presented.

A basic understanding of magnetic resonance physics should be provided, including the following: 1) the physics of magnetic resonance as it relates to image intensity and contrast, including flow, T1, T2, density of nuclear species (e.g., proton), and contrast agents; 2) sources of artifacts, including motion, arrhythmias, and metal objects; 3) safety of implanted devices (e.g., pacemakers, automatic implantable cardioverter-defibrillators), external ferromagnetic devices, and gadolinium-based contrast agents (for a summary of safety issues in CMR, see [www.mrisafety.com](http://www.mrisafety.com)); and 4) basic post-processing approaches and analyses.

## Hands-On Experience

Hands-on experience is not necessary for Level 1.

## Level 2: Specialized Training (at Least 3 Months)

Training for Level 2 should include the CMR experience described for Level 1. Level 2 is for those trainees who wish to practice the clinical subspecialty of CMR, including independent interpretation of CMR studies. Level 2 trainees must have at least 3 months of dedicated CMR training (where 1 month is defined as 4 weeks and 1 week is defined as 35 h), including the basic elements listed in the following text. The trainee would be expected to become familiar with the CMR techniques listed in Table 1.

## Background

An understanding of CMR physics should be substantially more advanced than in Level 1 training (see the following text).

## Didactic Activities

**Interpretation of CMR studies.** During their 3 or more months of experience, trainees should actively participate in daily CMR study interpretation under the direction of a Level 2 or Level 3 (preferred) CMR-qualified physician-mentor. For all studies in which other cardiac imaging data are available, such information should be correlated with CMR data. The trainee should interpret at least 150 CMR examinations during this training period, including 50 for which the trainee is present during the scanning procedure, ideally as the primary operator, and is the primary interpreter. Up to 50 of the 100 examinations for which the trainee is not the primary interpreter can be derived from established teaching files, journals and/or textbooks, or electronic/on-line courses. Careful documentation of all case material and the details of the way in which the case was derived are essential.

**Lectures and self-study in CMR.** Course work would include the components for Level 1 training but should also include more advanced lectures and reading materials. This work, with parallel reading, should continue for the duration of the traineeship. Course work should include the following:

1. Physics: Trainees should receive didactic lectures from a CMR-trained physician (who has achieved Level 2 or 3 in CMR) and/or physicist on the basic physics of magnetic resonance in general and as it relates to CMR in particular. The content should include the same materials as in Level 1 (basic) plus lectures with supportive reading on the following topics:
  - a. Image formation, including k-space, gradient echo, spin echo, fast spin echo, echo planar, spiral, steady state free precession (SSFP), and parallel imaging
  - b. Specialized imaging sequences, including flow and motion, phase imaging, time of flight, contrast agents, and radiofrequency tagging
  - c. Hardware components, including the elements of gradient coil design, receiver coils, and digital sampling
2. Applications, interpretation, indications, and contraindications: Level 2 didactic activities should include an understanding of the sensitivity, specificity, accuracy, utility, costs, acquisition approaches, and disadvantages of all of the contemporary techniques in CMR. The following techniques should be covered in the didactic program:
  - a. Imaging of structure and tissue characterization (T1, T2, spin echo, gradient echo, SSFP, image contrast mechanisms, and fat suppression)
  - b. Imaging of function (cine and tagged cine magnetic resonance including SSFP imaging approaches)



- c. Volumetric imaging of mass, biventricular volumes, and ejection fraction (using cine magnetic resonance imaging)
- d. Flow imaging (e.g., velocity-encoded techniques)
- e. Imaging of myocardial infarction, scarring, and viability assessment (delayed contrast-enhancement imaging)
- f. Pharmacologic stress testing with evaluation of ventricular function and/or first-pass perfusion imaging using a contrast agent
- g. Magnetic resonance angiography (vascular)
- h. Mechanisms, types, and pharmacologic aspects of CMR contrast agents
- i. Electrocardiogram and peripheral pulse gating and triggering including timing of image acquisition within the R-R interval, motion artifacts and their effects on CMR images; respiratory motion suppression methods (e.g., breath-holding and navigators)
- j. Magnetic resonance spectroscopy methods (e.g., depth resolved surface coil spectroscopy, or DRESS, and 3-dimensional Fourier transform approaches)
- k. CMR image analysis and post-processing tools
- l. Contraindications for CMR study
- m. Incidental findings suggesting pathology outside of the cardiovascular system

### Evaluation

The person responsible for the CMR training program must be responsible for assessing the competence of the CMR trainee at the completion of the program. This is accomplished by examining the ability of the trainee in the understanding of the acquisition methods, the interactive role of the operator during the performance of CMR studies, and the interpretation of the data acquired during daily reading sessions. This may be supplemented by formal didactic training.

### Level 3: Advanced Training (at Least 12 Months for Those Interested in Pursuing a Clinical or Academic Career in CMR or Directing a CMR Laboratory)

Level 3 CMR training represents the highest level of training and would enable the cardiovascular trainee to

pursue a clinical or academic career in CMR and to direct a CMR laboratory. Level 3 training in CMR could be obtained as part of a 3- or 4-year cardiology fellowship. In addition to the recommendation for Level 2, the Level 3 academic program should include active participation in an ongoing basic and/or clinical CMR research, with independent responsibility for a specific portion of that research. Focused research work with publication of 1 or more manuscripts is an essential component of Level 3 training. Level 3 training must be performed under the guidance of at least one Level 3-trained CMR physician.

In parallel with research activities, the Level 3 trainee must participate in clinical imaging, which should include supervised interpretation of at least 300 CMR cases. The trainee must be physically present and involved in the acquisition and the primary interpretation of at least 100 CMR cases. In the remaining 200 cases, the trainee should review at least 100 of these cases with the Level 3 mentor. The remaining cases can be derived from established teaching files, journals and/or textbooks, or electronic/on-line courses. Careful documentation of all case material and details of the way in which the case was derived are essential.

Knowledge of magnetic resonance physics must be more advanced than that included in Level 2 training and include the following:

1. An understanding of why certain specialized imaging sequences are applicable for specific clinical protocols, including imaging of heart function, coronary arteries, perfusion, delayed enhancement, and peripheral arteries.
2. Basic understanding of the clinically applicable spectroscopic methods.
3. The essentials of data collection, including capturing of digital data, the maintenance of accurate databases and records, signal processing, and the approaches for quantitating data.

### Evaluation

Evaluation should be similar to that of Level 2.

### Summary of recommendations

The overall requirements for training in CMR are summarized in Table 3.

**Table 3** Summary of Requirements for Each Level of CMR Training

Level	Duration of Training (Months)	Number of Cases
1	1	25+ mentored interpretations (by a Level 2- or Level 3-trained physician)
2	3 to 6*	150+ mentored interpretations (by a certified Level 2- or Level 3- [preferred] qualified CMR physician, including at least 50 as primary interpreter (and operator, if possible)†
3	At least 12 of training*	300+ mentored interpretations by a Level 3-qualified CMR physician including 100+ as primary interpreter (and operator, if possible)†

\*This time represents the number of months spent reviewing cases, and interpreting, performing, and learning about cardiovascular magnetic resonance (CMR), and need not be a consecutive block of time, but at least 50% of the time should represent mentored laboratory experience. †The case recommendations may include studies from an established teaching file, previous CMR cases, journals and/or textbook, or electronic/on-line courses/continuing medical education. No less than 50% of the cases should be from those performed at the mentoring CMR laboratory.

This is an update of the 2006 document that was written by Matthew J. Budoff, MD, FACC—Chair; Stephan Achenbach, MD (Society of Cardiovascular Computed Tomography Representative); Zahi A. Fayad, PhD, FACC (Society of Atherosclerosis Imaging and Prevention Representative); Daniel S. Berman, MD, FACC; Michael Poon, MD, FACC; Allen J. Taylor, MD, FACC; Barry F. Uretsky, MD, FACC (Society for Cardiovascular Angiography and Interventions Represent-

tative); and Kim Allan Williams, MD, FACC (American Society of Nuclear Cardiology Representative).

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**Key Words:** ACCF Training Statement ■ COCATS 3 ■ cardiovascular imaging ■ cardiovascular magnetic resonance ■ steady state free precession.

## APPENDIX 1. AUTHOR RELATIONSHIPS WITH INDUSTRY—ACCF 2008 RECOMMENDATIONS FOR TRAINING IN ADULT CARDIOVASCULAR MEDICINE CORE CARDIOLOGY TRAINING (COCATS 3)—TASK FORCE 12: TRAINING IN ADVANCED CARDIOVASCULAR IMAGING (CARDIOVASCULAR MAGNETIC RESONANCE [CMR])

Name	Consultant	Research Grant	Scientific Advisory Board	Speakers' Bureau	Steering Committee	Stock Holder	Other
Dr. Raymond J. Kim	• Mallinckrodt	• Siemens	None	None	None	None	• Heart IT—Founder
Dr. Christopher M. Kramer	• GE Healthcare	• Astellas • Novartis	None	• GE Healthcare	None	None	• Siemens—Research support
Dr. Warren J. Manning	None	None	None	None	None	None	None
Dr. Gerald M. Pohost	None	• GE Healthcare	None	• Takeda Pharmaceuticals	None	None	None

This table represents the relationships of committee members with industry that were reported by the authors as relevant to this topic. It does not necessarily reflect relationships with industry at the time of publication.

## APPENDIX 2. PEER REVIEWER RELATIONSHIPS WITH INDUSTRY—ACCF 2008 RECOMMENDATIONS FOR TRAINING IN ADULT CARDIOVASCULAR MEDICINE CORE CARDIOLOGY TRAINING (COCATS 3)—TASK FORCE 12: TRAINING IN ADVANCED CARDIOVASCULAR IMAGING (CARDIOVASCULAR MAGNETIC RESONANCE [CMR])

Name*	Affiliation	Consultant	Research Grant	Scientific Advisory Board	Speakers' Bureau	Steering Committee	Stock Holder	Other
Dr. Rick A. Nishimura	• Official—Board of Trustees	None	None	None	None	None	None	None
Dr. Raymond Y. K. Kwong	• Organizational—Society for Cardiovascular Magnetic Resonance	None	None	None	None	None	None	None
Dr. Nathaniel Reichek	• Organizational—Society for Cardiovascular Magnetic Resonance	None	None	None	None	None	None	None

The individuals listed above did not declare any relationships with industry. This table represents the relationships of peer reviewers with industry that were reported by the authors as relevant to this topic. It does not necessarily reflect relationships with industry at the time of publication. \*Names are listed in alphabetical order with each category of review.

## Task Force 13: Training in Advanced Cardiovascular Imaging (Computed Tomography)

*Endorsed by the American Society of Nuclear Cardiology, Society of Atherosclerosis Imaging and Prevention, Society for Cardiovascular Angiography and Interventions, and Society of Cardiovascular Computed Tomography*

Matthew J. Budoff, MD, FACC, *Chair*

Stephan Achenbach, MD (*Society of Cardiovascular Computed Tomography Representative*),

Daniel S. Berman, MD, FACC, Zahi A. Fayad, PhD, FACC (*Society of Atherosclerosis Imaging and Prevention Representative*), Michael Poon, MD, FACC, Allen J. Taylor, MD, FACC,

Barry F. Uretsky, MD, FACC (*Society for Cardiovascular Angiography and Interventions Representative*),

Kim Allan Williams, MD, FACC (*American Society of Nuclear Cardiology Representative*)

Computed tomography (CT) is one of the most rapidly evolving techniques for assessing cardiovascular anatomy. The complex nature of the imaging devices and anatomy and the rapidly advancing uses of these modalities require the trainee to be introduced to this modality. Clinical application of CT encompasses noncontrast (coronary calcium evaluation), contrast (CT angiography and function), and hybrid studies (combining nuclear cardiac scanning with CT). Computed tomography, like invasive catheterization, provides information concerning cardiovascular anatomy and function (i.e., ejection fraction). Hybrid devices are rapidly evolving to incorporate state-of-the-art, high-speed multi-detector computed tomography (MDCT) technology, along with the latest positron emission tomography (PET) and single-photon emission computed tomography (SPECT) detector systems. Current hybrid systems (MDCT plus nuclear) provide attenuation correction for SPECT and PET thereby further improving the diagnostic accuracy of more traditional radionuclide techniques.

It should be noted that the guidelines for fellows-in-training outlined here and those for physicians in practice previously published have slightly different targets for time and experience (1). The fellows-in-training are expected to get exposure to CT throughout their training, incorporating the results with echocardiography, nuclear cardiology, cardiovascular magnetic resonance (CMR), and cardiac catheterization when appropriate. Physicians in practice who are first being exposed to cardiovascular computed tomography (CCT) will most likely not have this comprehensive approach. Guidelines for practicing physicians are published by the American College of Cardiology/American Heart Association Task Force on Clinical Competence in Computed Tomography and Magnetic Reso-

nance (2). Fellowship training in CT should include instruction in the basic aspects, but only those fellows who go beyond the basic level are trained sufficiently for independent interpretation of CT studies. Every trainee should be educated in the use of CT and in cardiovascular anatomy, physiology, and pathophysiology, as well as physics of CT and radiation generation and exposure. As many CCT studies are done before and after intravenous administration of iodinated contrast, a thorough understanding of contrast injection methods, adverse events and their treatments, and contrast kinetics in patients will be required. In particular, knowledge is needed in the methods of contrast-enhanced imaging of the pericardium, right ventricle, right atrium, and superior and inferior vena cavae as well as imaging of the left heart, surrounding great vessels, and the central circulation.

By the end of the fellowship, trainees should have been exposed to CCT studies, both in interpretation and performance. It is currently recognized that many programs might not have availability of CCT, and options should be made available to obtain training at a different facility if the primary program cannot accommodate. The trainee should master the relation between the results of the CT examination and findings of other cardiovascular tests, such as catheterization, nuclear cardiology, magnetic resonance, and echocardiography. Every cardiology fellow should be exposed to and be familiar with the technical performance, interpretation, strengths, and limitations of CT and its multiple clinical applications. It is recognized that CT is an evolving technology in a rapid phase of development and 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 cardiology fellows must attain at least the first level of expertise. This entails under-

Table 1

**Requirements for CCT Study Performance and Interpretation to Achieve Level 1, 2, and 3 Clinical Competence**

	Cumulative Duration of Training	Minimum Number of Mentored Examinations Present During Performance	Minimum Number of Mentored Examinations Interpreted
Level 1	1 month*	—	50†
Level 2	2 months*	35	150 CCT cases†
Level 3	6 months*	100	300 CCT cases†

\*This represents cumulative time spent interpreting, performing, and learning about cardiovascular computed tomography (CCT), and need not be a consecutive block of time, but at least 50% of the time should represent supervised laboratory experience. In-lab training time is defined as a minimum of 35 h/week. †The caseload recommendations may include studies from an established teaching file, previous CCT cases, journals and/or textbook, or electronic/on-line courses/continuing medical education.

standing the basic principles, indications, applications, and technical limitations of CT and the interrelation of this technique with other diagnostic methods. This level will not qualify a trainee to perform CT or to interpret CT independently.

Level 2 is defined as the minimum recommended training for a trainee to independently perform and interpret CCT. Level 3 expertise would enable the trainee to direct a CT laboratory.

**General Standards**

The CT laboratory in which training is undertaken should be under the direct supervision of a full-time qualified director (or directors) who has achieved Level 3 training. Training guidelines in the present document are primarily directed to trainees performing CCT examinations in adult patients with acquired and congenital heart disease. Participation of additional full- or part-time faculty is highly desirable because of the multiple applications of CT (i.e., attenuation correction of nuclear imaging, noncontrast and contrast studies, function, structure, congenital, and vascular imaging). The CCT examination is an operator-dependent procedure in which it is possible to introduce confounding artifacts or omit data of diagnostic importance. Hands-on training is important, not to develop technical expertise in acquiring images, but rather as a valuable aid to learn tomographic cardiac anatomy, integrate planar views into a 3-dimensional framework (nonplanar and oblique/multiplanar imaging), and understand the distinction between reliable and unreliable data. Understanding the source of the artifacts (breath-holding, gating, or arrhythmias) present on the images is vital.

**Content of the Training Program**

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. It is recommended that fellows keep a log documenting their involvement in CT studies, as well as

their exposure to appropriate continuing medical education hours.

The recommendations for all levels of training in the following text represent a cumulative experience, and it is expected that for many fellows, the training will not be continuous. A summary of the training requirements is given in Table 1. For all Level 2 and Level 3 requirements, the minimum time in a CCT laboratory is 50% of the time listed. The remaining time required can be garnered by supervised time, CT exposure in courses, case studies, CD/DVD training, time at major medical meetings devoted to performance of CCT, or other relevant educational training activities, to name just a few examples. The caseload recommendations may include studies from an established teaching file, previous CCT cases, and electronic/on-line experience or courses.

**Description of Cases**

Activities that qualify for the 35 cases where the candidate is “physically present and involved in the acquisition and interpretation of the case”:

The following 3 elements must be met:

1. Candidate must be present in the scanning suite (or control room) or in the presence of a video feed during CT raw data acquisition and image reconstruction from that raw data.
2. Interactive manipulation of the reconstructed data sets for evaluation of the scan must be performed by the candidate. Individual cases should include all components of cardiac structure and function as well as noncardiac structures as indicated.
3. During this data evaluation process, there must be an opportunity for interaction between the candidate and trainer.

Activities that qualify for the additional 100 cases include:

1. A maximum of 50 cases from an educational CD or presentation granting continuing medical education credit that contains CT data review, clinical information, and appropriate clinical correlative information (e.g., invasive coronary angiographic images).
2. Up to 100 but not less than 50 of the cases must involve interactive manipulation of reconstructed data sets using a workstation or equivalent.

**Level 1 Training (1 Month, at Least 50 Examinations Interpreted)**

Level 1 is defined as the minimal introductory training for familiarity with CCT, but it is not sufficient for independent interpretation of CCT images. The individual should have intensive exposure to the methods and the multiple applications of CCT for a period of at least 1 month. The time commitment for training is defined as 35 h per week. This



should provide a basic background in CCT for the practice of adult cardiology. During this cumulative 4-week experience, individuals should have been actively involved in CCT interpretation under the direction of a qualified (preferably Level 3–trained) physician-mentor (1). There should be a mentored interpretative experience of at least 50 cases for all studies in which other cardiovascular imaging methods are also available, correlation with CCT findings, and interpretation. Mentored interpretative experience may include studies from an established teaching file or previous CCT cases and also includes the potential for CD/DVD and on-line training.

For all levels of competence, it is expected that the candidate will attend lectures on the basic concepts of CCT and include parallel self-study reading material. A basic understanding of CCT should be achieved including: the physics of CCT imaging, the basics of CCT scan performance, safety issues in CCT performance, side effects (and their treatment) of medications used currently including beta blockers and nitrates, post-processing methods, and basics of CCT interpretation as compared with other cardiovascular imaging modalities including echocardiography, nuclear cardiology, CMR, and invasive cardiac and vascular x-ray angiography. Furthermore, auxiliary cardiac diagnostics should include recognition of ventricular hypertrophy, dilation, valve pathologies such as mitral stenosis/annular and leaflet calcification, cardiac masses, aortic valve pathology (number of cusps) and calcification/aortic stenosis, pericardial and infiltrative myocardial disease, internal mammary arteries, left atrial and pulmonary and coronary venous abnormalities, thoracic aortic pathology, and saphenous vein grafts.

### **Level 2 Training (2 Months of Training and Interpretation of 50 Noncontrast and 150 Contrast Studies Total, 35 of Which the Fellow is Present During Performance)**

Level 2 is defined as the minimum recommended training for a physician to independently perform and interpret CCT. To accomplish this, the fellow should devote an additional 1 month, or the equivalent, interpreting a minimum of 150 contrast studies total. The noncontrast and contrast studies may be evaluated in the same patients. Of these, at least 35 cases should be performed with the fellow present under appropriate supervision. Competence at this level implies that the fellow is sufficiently experienced to interpret the CT examination accurately and independently. Continued exposure to special CT procedures, such as hybrid studies with nuclear imaging and integration of images into electrophysiologic procedures, is appropriate during Level 2 training.

Didactic studies should include advanced lectures, reading materials, and formal case presentations. These didactic

studies should include information on the sensitivity, specificity, accuracy, utility, costs, advantages, and disadvantages of CCT as compared with other cardiovascular imaging modalities. Each fellow should receive documented training from a CCT mentor and/or physicist on the basic physics of CT in general and on CCT in particular. Lectures will include discussions of anatomy, contrast administration and kinetics, and the principles of 3-dimensional imaging and post-processing. The fellow should also receive training in principles of radiation protection, the hazards of radiation exposure to both patients and CT personnel, and appropriate post-procedure patient monitoring.

A fellow with Level 2 and Level 3 training should demonstrate clear understanding of the various types of CT scanners available for cardiovascular imaging (electron beam tomography and MDCT) and understand, at a minimum, the common issues related to imaging, post-processing, and scan interpretation including:

- Indications and risk factors that might increase the likelihood of adverse reactions to contrast media
- Radiation exposure factors
- CT scan collimation (slice thickness)
- CT scan temporal resolution (scan time per slice)
- Table speed (pitch)
- Field of view
- Window and level view settings
- Algorithms used for reconstruction
- Contrast media
- Presence and cause of artifacts
- Post-processing techniques and image manipulation on work stations
- Total radiation dose to the patient

### **Incidental Noncardiac Findings**

During a CCT examination, the standard use of a small field of view (e.g., limited lung fields) precludes complete evaluation of the entire thorax. However, to address the possibility that significant noncardiac imaging findings, (e.g., aortic disease, hilar adenopathy, large pulmonary nodules, and pulmonary emboli) might be present on a CCT scan, specific interpretation of the extra-cardiac fields should be performed. The patient and the referring physician should understand that the focus of the CCT examination is the detection of cardiac disease, and the scan does not encompass the entire lung field. Regarding the cardiovascular medicine specialist performing CCT, the Task Force recognizes and endorses education and training of such individuals in the recognition of incidental scan findings in support of quality imaging care of patients with cardiovascular disease. These cases require referral to a specialist or a radiologist with expertise in chest imaging. To this end, it is felt that Level 2 and Level 3 training should include the review of all CCT cases for noncardiac findings.

The review of 150 CCT cases for incidental findings should include the review of a dedicated teaching file of 25 CCT cases featuring the presence of significant noncardiac pathology. Furthermore, part of the core curricula for Level 2 and Level 3 should include specific lectures on non-CCT pathology.

### **Level 3 Training (Total 6 Months of Training, Inclusive of Level 1 and 2, 150 Additional Examinations)**

Level 3 training represents the highest level of exposure/expertise that would enable an individual to serve as a director of an academic CCT section or director of an independent CCT facility or clinic. This individual would be directly responsible for quality control and training of technologists and be a mentor to other physicians seeking such training. For a trainee desiring to direct a CT laboratory (Level 3), a total of 6 months of training devoted to CT is required, with an additional 6 months experience which can be obtained concurrently with training in other imaging modalities. To attain Level 3, candidates should be involved with interpretation of at least 100 noncontrast and 300 contrast CCT examinations. For at least 100 of these cases, the candidate must be physically present and be involved in the acquisition and interpretation of the case. At the discretion of the director, increasing independence in interpretation and over-reading of CT studies can be implemented.

In addition to the recommendations for Level 1 and Level 2 training, Level 3 training should include active and ongoing participation in a basic research laboratory, clinical research, or graduate medical teaching. Level 3 training should also include exposure to administrative aspects of running a CT laboratory and documented experience in CT research, as well as understanding of new and evolving CT and nuclear/CT technologies. 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 hybrid studies and electrophysiologic studies (integration of CT images with fluoroscopic images to provide enhanced visualization for ablation).

### **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. For the practicing physician interested in obtaining equivalent training, please refer to the recent report of the ACC/AHA/American College of Physicians Task Force on Clinical Competence on Computed Tomography and Magnetic Resonance (2).

### **Vascular CT Imaging**

Vascular CT, at this point, represents an optional portion of training. As a cardiovascular specialist, it is expected that the cardiology fellow acquire skills beyond the cardiac structures and coronary tree. It is well established that CT has a high sensitivity and specificity for vascular disease outside the heart. Carotid, renal, and peripheral imaging has been well validated, even prior to MDCT availability. The additional benefits of large volumes of coverage per rotation with the newer MDCT scanners allows for very rapid imaging of the carotid, renal, or peripheral vascular bed, with minimal contrast requirements and great spatial resolution. The lack of motion of these vascular beds makes imaging less difficult for interpretation than coronary evaluation. Furthermore, the acquisition of the images are much easier for peripheral beds, and physics, acquisition parameters, and reconstruction techniques learned during cardiac evaluations are similar for vascular imaging. However, vascular imaging requires additional knowledge of the anatomy, as well as pathophysiology of each vascular bed. For the candidate to achieve Level 2 competence in cardiac and vascular CT, it is recommended that an additional 35 mentored contrast cases be included (over the 150 case requirement for cardiac), specifically targeting peripheral vascular beds. To achieve Level 3 for cardiac and vascular CT, 100 additional mentored vascular cases should be reviewed by the trainee. There is currently no pathway for vascular CT imaging without meeting the Level 2 or Level 3 criteria for CCT outlined in Table 1.

### **Trainee Evaluation**

Even in academic centers, where most trainees are taught, there is currently a failure to provide ideal CCT services to cardiovascular patients. The individual must have knowledge of the specific equipment to be used in each procedure, including x-ray contrast, CCT physics, and radiation exposure. Assessment of technical performance is best done by direct oversight during interpretation of procedures. The competence of all cardiology trainees in CCT should be documented by both the cardiovascular program director and the program director of the CCT laboratory. Records must be maintained of all evaluations and of the number and type of all laboratory procedures performed by each trainee. Numbers of cases that the trainee is involved in, both in the live acquisition of cases, as well as the number of cases the trainee is involved in the interpretation is critical for competence in CCT. The use of examinations (e.g., the Cardiac Computed Tomography Self-Assessment Program [CCTSAP]) at the end of CCT training is strongly encouraged. All procedures performed by the trainee must be documented electronically or in a logbook.

*This is an update of the 2006 document that was written by Matthew J. Budoff, MD, FACC—Chair; Stephan Achen-*

*bach, MD (Society of Cardiovascular Computed Tomography Representative); Zahi A. Fayad, PhD (Society of Atherosclerosis Imaging and Prevention Representative); Daniel S. Berman, MD, FACC; Michael Poon, MD, FACC; Allen J. Taylor, MD, FACC; Barry F. Uretsky, MD, FACC (Society for Cardiovascular Angiography and Interventions Representative); and Kim Allan Williams, MD, FACC (American Society of Nuclear Cardiology Representative).*

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**TASK FORCE 13 REFERENCES**

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the American Society of Nuclear Cardiology, Society for Cardiovascular Angiography and Interventions, Society of Atherosclerosis Imaging and Prevention, and Society of Cardiovascular Computed Tomography. *J Am Coll Cardiol* 2006;47:915–20.

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**Key Words:** ACCF Training Statement ■ COCATS 3 ■ cardiovascular imaging ■ computed tomography ■ positron emission tomography ■ single-photon emission computed tomography ■ cardiovascular magnetic resonance.

**APPENDIX 1. AUTHOR RELATIONSHIPS WITH INDUSTRY—ACCF 2008 RECOMMENDATIONS FOR TRAINING IN ADULT CARDIOVASCULAR MEDICINE CORE RADIOLOGY TRAINING (COCATS 3)—TASK FORCE 13: TRAINING IN ADVANCED CARDIOVASCULAR IMAGING (COMPUTED TOMOGRAPHY)**

Name	Consultant	Research Grant	Scientific Advisory Board	Speakers' Bureau	Steering Committee	Stock Holder	Other
Dr. Stephan Achenbach	• Bristol-Myers Squibb Imaging	• Siemens	None	• Bracco • Siemens	None	None	None
Dr. Daniel S. Berman	• Tyco-Mallinckrodt	• Astellas • Bristol-Myers Squibb Imaging • GE Healthcare	• Spectrum Dynamics	None	None	• Spectrum Dynamics	• Cedars-Sinai Medical Center—Software royalties
Dr. Matthew J. Budoff	None	None	None	• GE Healthcare	None	None	None
Dr. Zahi A. Fayad	None	None	None	None	None	None	None
Dr. Michael Poon	None	None	• Chase Medical • Siemens • TeraRecon	None	None	None	None
Dr. Allen J. Taylor	None	• Kos Pharmaceuticals	• Pfizer	• Kos Pharmaceuticals	None	None	None
Dr. Barry F. Uretsky	None	None	None	None	None	None	None
Dr. Kim Allan Williams	• King Pharmaceuticals	• Bristol-Myers Squibb Imaging • CV Therapeutics • GE Healthcare	• GE Healthcare	• Astellas • GE Healthcare	None	None	None

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**APPENDIX 2. PEER REVIEWER RELATIONSHIPS WITH INDUSTRY—ACCF 2008 RECOMMENDATIONS FOR TRAINING IN ADULT CARDIOVASCULAR MEDICINE CORE CARDIOLOGY TRAINING (COCATS 3)—TASK FORCE 13: TRAINING IN ADVANCED CARDIOVASCULAR IMAGING (COMPUTED TOMOGRAPHY)**

Name*	Affiliation	Consultant	Research Grant	Scientific Advisory Board	Speakers' Bureau	Steering Committee	Stock Holder	Other
Dr. David J. Clardy	• Official—Board of Governors	None	None	None	None	None	None	None
Dr. Rick A. Nishimura	• Official—Board of Trustees	None	None	None	None	None	None	None
Dr. John J. Mahmarian	• Organizational—American Society of Echocardiography	None	None	None	None	None	None	None
Dr. Mylan C. Cohen	• Organizational—American Society of Nuclear Cardiology	None	None	None	None	None	None	None
Dr. Harvey S. Hecht	• Organizational—Society of Atherosclerosis Imaging and Prevention	None	None	None	None	None	None	None
Dr. Paolo Raggi	• Organizational—Society of Atherosclerosis Imaging and Prevention	None	None	None	None	None	None	None
Dr. Amjad Almahameed	• Organizational—Society for Vascular Medicine	• GlaxoSmithKline	None	None	• Aventis • GlaxoSmithKline • Sanofi	None	• GlaxoSmithKline	None
Dr. Joshua A. Beckman	• Organizational—Society for Vascular Medicine	None	None	None	None	None	None	None
Dr. Susan M. Begelman	• Organizational—Society for Vascular Medicine	None	None	None	None	None	None	None
Dr. Leonardo C. Clavijo	• Organizational—Society for Vascular Medicine	None	None	None	None	None	None	None
Dr. James B. Froehlich	• Organizational—Society for Vascular Medicine	None	None	None	None	None	None	None
Dr. Scott Kinlay	• Organizational—Society for Vascular Medicine	None	None	None	None	None	None	None
Dr. Emile R. Mohler, III	• Organizational—Society for Vascular Medicine	None	None	None	None	None	None	None
Dr. John E. Brush, Jr.	• Content—Individual Reviewer	None	None	None	None	None	None	None
Dr. Marcello DiCarli	• Content—Individual Reviewer	• Bracco • Bristol-Myers Squibb Imaging • GE Healthcare	• Astellas • Bracco • Bristol-Myers Squibb Imaging • GE Healthcare	• Bracco • Bristol-Myers Squibb Imaging • GE Healthcare	• Astellas • Bracco • GE Healthcare	None	None	None

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