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ACC Revised Recommendations for Training in Adult Cardiovascular Medicine Core Cardiology Training II (COCATS 2)

(Revision of the 1995 COCATS Training Statement)

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Introduction

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In 1995, guidelines for training in adult cardiovascular medicine were published as an outgrowth of a consensus statement emanating from the Core Cardiology Training Symposium (COCATS) held at Heart House, Bethesda, Maryland, June 27 to 28, 1994 (1). Since publication of the proceedings of that consensus conference in the *Journal of the American College of Cardiology*, the term "COCATS" has been used when referring to the American College of Cardiology training guidelines for fellowship programs. Since the first COCATS document was published in 1995, significant advances have been made in cardiovascular science, and new technologies have emerged. This necessitated a revision to these training guidelines.

The current revision was accomplished by the formation of small task forces that included representatives from the subspecialty societies where appropriate. These task forces reviewed the 1995 COCATS task force reports and made revisions, additions, and deletions based on data from the literature and their expert opinion. Major changes were most often related to maturing of either new subspecialty areas in cardiology or the emergence of new technology into accepted practice. Numbers of procedures to be performed, interpreted, or both were made consistent with volume recommendations found in the American College of Cardiology (ACC)/American Heart Association (AHA) practice guidelines, ACC/AHA/American College of Physicians-American Society of Internal Medicine (ACP-ASIM) clinical competence statements, or other relevant consensus documents.

The Task Force reports were peer reviewed by the following ACC committees: Cardiac Catheterization and Intervention Committee (Task Force 3); Echocardiography Committee (Task Force 4); Clinical Electrophysiology Committee (Task Force 6); Clinical Research Committee (Task Force 7); Heart Failure and Transplant Committee (Task Force 8); Congenital Heart Disease and Pediatric Cardiology Committee (Task Force 9); Prevention of Cardiovascular Disease Committee (Task Force 10); Peripheral Vascular Committee (Task Force 11); Cardiovascular Imaging Committee (Task Force 12), as well as 5 members of the ACC Board of Governors and 10 training directors. Several organizations also reviewed the document including the American Heart Association (entire document); Society for Cardiac Angiography and Interventions (Task Force 3); American Society of Echocardiography (Task Force 4); American Society of Nuclear Cardiology (Task Force 5); North American Society of Pacing and Electrophysiology (Task Force 6); Heart Failure Society (Task Force 8); Society of Vascular Medicine and Biology (Task Force 11); and the Society of Cardiac Magnetic Resonance (Task Force 12).

The American Board of Internal Medicine (ABIM) subspecialty board on cardiovascular disease still requires 3 years of cardiology fellowship training. An additional year of training is required by the ABIM to sit for the certification examinations for added qualifications in clinical cardiac electrophysiology or interventional cardiology. As outlined in this document, additional years of training are also recommended for those trainees who desire advanced expertise in specialized areas, those who want dedicated time for basic and/or clinical research training, or both. Throughout this revision of COCATS, recommendations for such advanced training experiences are proposed relative to the discipline of cardiovascular medicine being addressed.

In the 1995 COCATS guidelines, 10 task force reports pertaining to overall training in clinical cardiology (Task Force 1) and training in specific specialized areas of cardiovascular medicine (e.g., echocardiography, nuclear cardiology, cardiac catheterization, and electrophysiology) were presented. In this revised document, 2 additional task force reports are published. These are entitled "Training in Vascular Medicine and Peripheral Catheter-Based Interventions" and "Training in Cardiovascular Magnetic Resonance." The vascular medicine task force report emphasizes that cardiologists must have adequate basic training in vascular medicine to acquire a sufficient knowledge base to care for the many patients with peripheral vascular disease. The highest level of training in this area is focused on the acquisition of skills for catheter-based vascular interventions. A career track in vascular medicine for cardiology trainees is outlined in detail. The other new task force report relates the significant advances that have been made in the application of magnetic resonance imaging to cardiac and vascular diseases.

Many of the original 10 task force reports have been substantially revised in accordance with advances in those particular training disciplines. The need for a clinical core of 24 months with a minimum of 9 months in nonlaboratory clinical practice activities is sustained in the report from Task Force 1, which deals with overall training in clinical cardiology. The importance of active participation in research activities is again emphasized in this COCATS revision, and the Task Force 7 report outlines various approaches that can be pursued to fulfill this important academic training requirement for cardiology trainees. The need for core training in long-standing procedural techniques, such as electrocardiography, ambulatory monitoring, and conventional stress testing, is clearly defined, and volumes of tests that must be performed and/or interpreted to achieve competence are again given.

Training in interventional cardiology as described in the Task Force 3 report is now limited to formal training programs in the United States that satisfy the basic standards developed by the American Council for Graduate Medical Education (ACGME) and are accredited by ACGME. These criteria must be met for candidates to be eligible to take the examination to obtain the certificate of added qualification in interventional cardiology from the ABIM (effective July 1, 2002). This Level 3 training must be achieved during a fourth year of dedicated fellowship experience. As described in the Task Force 4 report, which deals with training in echocardiography, exposure to transesophageal echocardiography and other special ultrasound procedures can commence with trainees undergoing Level 2 training. The task force members stated, however, that to become fully competent to perform these techniques independently, the completion of Level 2 training, as well as the supervised performance of the required number of special studies, is necessary. Guidelines for training in myocardial contrast echocardiography are now dealt with in detail in the revised echocardiography guidelines report by the task force. With respect to nuclear cardiology training guidelines in the Task Force 5 report, the importance of becoming knowledgeable in gated single-photon emission computed tomographic imaging is emphasized. With respect to cardiac electrophysiology, new guidelines are introduced regarding training for programming of all types of bradycardia pacing systems and implantable cardioverter-defibrillators (ICDs) and follow-up of patients with these devices. Training in heart failure and transplantation as outlined in the Task Force 8 report has been revised relative to the 1995 report. Recommendations for Level 1 training now include a minimum of 1 month of rotation on a dedicated heart failure service or incorporation of the 1 month in the non-laboratory months of training in those programs that have no separate heart failure service. Level 2 training in heart failure is now designated to encompass a total of 6 months. Details are described in the task force report.

As with the original document (1), in these revised training guidelines, fellow and trainee are used interchangeably, as are cardiovascular medicine and cardiology. Although numbers of procedures that should be completed to achieve levels of training are provided, the mere accomplishment of such numbers of procedures is not synonymous with excellence in their performance and interpretation. It is vital to the excellence of a training program that dedicated faculty members be available to supervise and critique performance and interpretation of procedures.

Throughout these task force reports, training is suggested at three levels:

Level 1—Basic training required of all trainees to be competent consultant cardiologists.

Level 2—Additional training in one or more specialized areas that enables the cardiologist to perform or interpret (or both) specific procedures at an intermediate skill level or engage in rendering cardiovascular care in specialized areas.

Level 3—Advanced training in a specialized area that enables a cardiologist to perform, interpret, and train others to perform and interpret specific procedures at a high skill level.

The ever-expanding knowledge base in basic cardiovascular science and cardiovascular medicine requires that all training programs have a rich assortment of didactic offerings for fellows. Case-based conferences, such as the traditional catheterization laboratory conference, are vital to train fellows and to develop their skills in evidence-based decision-making. Self-learning needs to be emphasized, and Internet-based, online educational programs, many of which are interactive, will play a greater role in a fellow's overall learning experience during fellowship and after training. Such didactic activities are outlined throughout the task force reports.

To view the complete COCATS recommendations, please visit the ACC Web site at http://www.acc.org/clinical/training/cocats2.pdf. These recommendations are considered current unless the ACC revises or withdraws them from publication.

Acknowledgment

The steering committee is most appreciative of the time and effort given to this COCATS revision by the Task Force members and reviewers who provided valuable input into the process. Carolyn Lanham, Eva Grace, Sylvia Polk-Burriss, and Dawn Phoubandith of the staff of the American College of Cardiology provided superb administrative support to the COCATS effort, and their contributions are recognized.

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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 take place after successful completion of at least 3 years of postdoctoral education and training in internal medicine. One exception relates to medical residents on the American Board of Internal Medicine (ABIM) Clinical Investigator track, which entails 2 years of internal medicine training coupled with 2 years of research training.

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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 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. 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 one 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 high-level 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, 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 cardiology, and vascular medicine); 2) 4 months in the cardiac catheterization laboratory; 3) 6 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 (ECG) monitoring; and 5) 2 months in arrhythmia management, permanent pacemaker management, and electrophysiology. A continuing ambulatory care experience for at least 1 half-day per week should occur 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 1 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.

The remaining year in the program should include a minimum of 6 months of 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 additional 6 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 during the final period of 6 months 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.

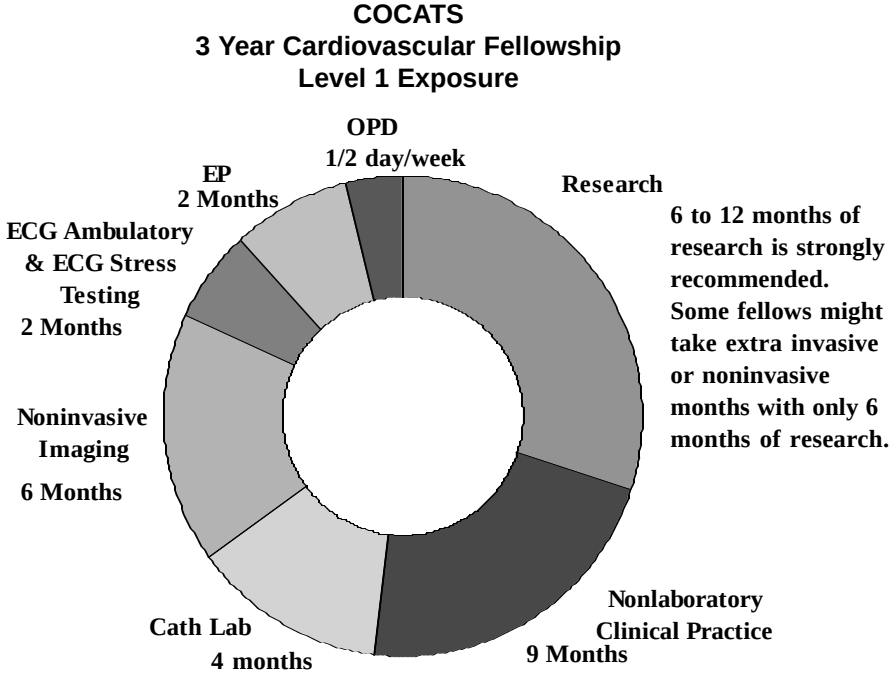

Figure 1. Level 1 exposure for 3-year cardiovascular fellowship. Cath = catheterization, ECG = electrocardiograph, EP = electrophysiology, and OPD = outpatient department.

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 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 one full-time equivalent 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

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 two other subspecialty training programs in internal medicine and a residency in internal medicine. Thus, the training program should enable the trainee to interact with other disciplines through the availability of collaborating consultants and 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 Task Forces 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 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 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 Task Force 6 report).

5. Facilities and faculty for training in cardiovascular research, including various basic science modalities, are important (see 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 preoperative and postoperative management of patients with cardiovascular

disease. Exposure to cardiac transplantation is strongly recommended (see 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 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 Task Force 10 and Task Force 11 reports).
10. Facilities for assessment of cardiopulmonary and pulmonary function, cardiovascular radiography, and magnetic resonance imaging must be available (see Task Force 12 report).
11. Appropriate expertise and instruction in preventive cardiology and risk factor modification, including management of lipid disorders, must be provided (see 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

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

All 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.

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.

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 acute coronary care. Exposure to and an understanding of the indications, risks, and benefits of cardiac surgery, coronary angioplasty, and the various phases of cardiac rehabilitation must be included.

Training in Ambulatory, Outpatient, and Follow-Up Care

Continued responsibility for outpatient cardiovascular patient management and consultations 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 postoperative 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 report by Task Force 2.

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 by Task Force 3. 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 Task Force 3.

Training in Echocardiography

All trainees must participate in the performance of echocardiography and Doppler echocardiography, including a minimum of 3 months of training. All trainees must understand the indications, risks, and benefits of transesophageal 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.

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 major evolving advanced imaging techniques, such as magnetic resonance imaging (MRI) and ultrafast and fast helical computed tomography.

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 trial design and biostatistics.

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.

Training in Preventive Cardiology

All trainees should know the principles of preventive cardiology, including vascular biology, genetics, epidemiology, biostatistics, clinical trials, outcomes research, clinical pharmacology, behavior change, and multidisciplinary care. 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.

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. All fellows should have a minimum of 1 month of general training in MRI. The fellow should supplement this experience with exposure to MRI studies throughout the clinical training program. Those who wish to interpret cardiovascular MRI studies or who desire advanced training must have additional training as designated in the Task Force 12 report.

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. Learning in pharmacology should recognize dietary, renal, and hepatic function and geriatric influence on drug therapy. The teaching of complementary medicine as it affects traditional cardiovascular therapy should be in the curriculum. The availability of educational programs in biostatistics, computer sciences, and biophysics is highly

desirable. 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. Training in medical economics, healthcare systems delivery, clinical decision making, preventive medicine, and healthcare 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 preoperative and postoperative management of patients with cardiovascular disease and various comorbid conditions.
3. *Anesthesia:* close collaboration with anesthesia colleagues in the preoperative and postoperative 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 radioactive lung scanning methods, as well as experience with management of patients with acute pulmonary disease.
5. *Obstetrics:* a solid knowledge of the interrelations 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 review 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 and become familiar with the fundamental principles of education, including skills in organization of conferences, lectures, and teaching materials. The teaching experience, often by 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 and supervising residents in internal medicine, as well as medical students, other cardiology trainees, and allied health personnel, and for working collaboratively with other healthcare 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.

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.

Appendix 1

Task Force	Area	Level	Minimal Number of Procedures	Cumulative Duration of Training (mo)	Cumulative Number of Procedures
1	Clinical cardiology	1		36	
2	Electrocardiography	1	500 to 3500*#		3500
		2			greater than 3500
	Ambulatory monitoring	1	150*		150
		2	75		225
	Exercise testing	1	200*		200
		2	100		300
3	Diagnostic catheterization	1	100	4	100
		2	200	8	300
	Interventional catheterization	3	250	20	550
4	Echocardiography	1	150	3	150
		2	150	6	300
		3	450	12	750
5	Nuclear cardiology	1	80 hours	2	80 hours
		2	300 cases	4 to 6	300+ cases
		3	600 cases	12	600+ cases
6	Electrophysiology,	1		2	
	pacing, and arrhythmias	2		6	
		3	150	24	150+ cases
7	Research	1		6 to 12†	
		2		24	
		3		24 to 36	
8	Heart failure	1		1†§	
	and transplantation	2		6	
		3		12	
9	Congenital heart disease	1		Core lectures†	
		2		12	
		3		24	40 Cath 300 TTE 50 TEE
	Preventive cardiology	1		1†§	
		2		6 to 12	
		3		12	
11	Vascular medicine and peripheral catheter-based intervention	1		2*	
	Vascular Medicine Specialist	2		14	400+ noninvasive cases**
	Peripheral Vascular Intervention	3		20††	160+§§
	Vascular Medicine Specialist plus Vascular Intervention	3		34‡‡	
12	Cardiovascular magnetic	1		1‡	50
	resonance imaging	2		3 to 6	150
		3		12	350

Cath = catheterization; TEE = transesophageal echocardiography; and TTE = transthoracic echocardiography.

*Can be taken throughout the training program.

#The committee strongly recommends that cardiologists achieve Level 2 training in ECG interpretation.

†Can be taken as part of 9 months of required nonlaboratory clinical practice rotation.

‡Can be taken as part of 6 months of noninvasive imaging rotation.

§It is assumed that trainees will obtain additional training in heart failure and preventive cardiology beyond the 1-month core training as part of the experience during other clinical months, such as consult services and CCU.

¶2 months of vascular medicine as defined by Level 1, plus 12 months of Level 2 training. Level 2 training is not a prerequisite for Level 3 training but is intended for individuals who want to become a vascular medicine specialist.

**In addition, observing 25 peripheral angiograms and 25 peripheral interventions

††Including 2 months of vascular medicine training as defined by Level 1, 8 months of diagnostic catheterization training, and 12 months of interventional lab training. Interventional training for Level 3 requires a 4th year. The 12 months of Level 2 training are not required for this interventional training year.

‡‡Including 2 months of Level 1 and 12 months of Level 2 vascular medicine training , 8 months of diagnostic catheterization training, and 12 months of interventional lab training.

§§Including 100 diagnostic peripheral angiograms, 50 peripheral interventions, and 10 thrombolysis/thrombectomies.

This is a revision of the January 1995 document that was written by Joseph S. Alpert, MD, FACC, Chair; William J. Arnold, MD, FACP; Bernard R. Chaitman, MD, FACC; C. Richard Conti, MD, FACC; Gordon A. Ewy, MD, FACC; Eric L. Michelson, MD, FACC; and Robert J. Myerburg, MD, FACC.

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

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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 two 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 some basic knowledge of electrocardiography, and the general internist should have a more advanced knowledge, the subspecialist in cardiology should be familiar with nearly all clinically encountered patterns of depolarization and repolarization and of arrhythmias. The trainee should understand their clinical implications and, equally important, their sensitivity and specificity and should be able to identify normal variants. The trainee should have sufficient basic knowledge to understand the physiologic mechanisms for arrhythmias and electrocardiographic (ECG) waveforms rather than to simply recognize patterns The recognition and understanding of the basis for the items included in the Appendix of this task force report are minimum requirements for each trainee.

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. These should be documented individually. This may be accomplished by one 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 Task Force 6 report). The trainee should be evaluated on an ongoing basis by the responsible faculty to determine that the trainee has integrated these knowledge bases. Because of variability in training in electrocardiography, to document the trainee's proficiency, an in-training examination in electrocardiography should be used and implemented by each training program. A standardized proficiency test in electrocardiography, the American College of Cardiology ECG Proficiency Test (ACCEPT), is currently available for individual assessment. The Adult Clinical Cardiology Self-Assessment Program (ACCSAP) contains a self-assessment examination in electrocardiography. Both examinations are implemented on a national basis and are useful in 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 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 new therapeutic modalities (e.g., implantable cardioverter-defibrillator devices).

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 printout) 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 Physicians (ACP)/American College of Cardiology (ACC)/American Heart Association (AHA) Task Force on Clinical Privileges in Cardiology (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 studies, implantable cardioverter-defibrillator devices, 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 seconds of real-time printout strips to 72 hours of full-disclosure data. Such ECG data often augment standard and ambulatory electrocardiography. Trainees will be experienced in the interpretation and limitations of telemetry data. Interpretive knowledge at this level supports the objectives of Level 2 training in electrophysiology, pacing, and arrhythmia management (see 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 protocols, blood pressure monitoring during exercise, and monitoring of the patient for adverse signs or symptoms.

The trainee must become proficient in the interpretation of commonly used measurements available from the exercise test. These include onset and offset of ischemic ST-segment depression, exercise-induced cardiac arrhythmias, magnitude and slope of ST-segment depression or elevation, ST/heart rate indexes, exertional hypotension, chronotropic incompetence, 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, establishing a written report, and importantly, understanding the diagnostic accuracy (sensitivity and specificity) and prog-

Table 1. Summary of Training Requirements for Electrocardiography, Ambulatory Monitoring, and Exercise Testing

Test Types	Level	Duration of Training	Cumulative Duration of Training	Minimal (Additional) No. of Examinations	Cumulative No. of Examinations
Electrocardiography	1	*	*	500 to 3500**	500 to 3500
	2	N/A	*		More than 3500
Ambulatory monitoring	1	*	*	150 Studies	150 Studies
	2	N/A	*	75 Studies	225 Studies
Exercise testing	1	*	*	200 Tests	200 Tests
	2	N/A	*	100 Tests	300 Tests

*Can be taken throughout the training program rather than during a dedicated 6-month rotation.
**The committee believes that all cardiology trainees should achieve Level 2 training in ECG interpretation.
N/A = not applicable.

nostic 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 ACP/ACC/AHA Task Force on Clinical Privileges in Cardiology.

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 2-month 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, stress-echocardiographic techniques, and nuclear cardiology (see 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 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.

Appendix: Electrocardiographic Knowledge Base and Interpretation

Anatomy and Electrophysiology

1. Anatomy of the specialized conducting system (sinoatrial node, atrioventricular [AV] 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 AV 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 reentrant tachycardia (common and uncommon type)
42. Nonparoxysmal junctional tachycardia-accelerated junctional rhythm
43. Atrioventricular reentrant 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 torsade 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 AV conduction
54. Third-degree AV block
55. Isorhythmic AV dissociation

Atrioventricular Block

56. First degree
57. Second degree; 2:1, Mobitz type I (Wenckebach), Mobitz type II, high-degree AV block
58. Third-degree AV 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 maximum exercise testing
100. Exercise-induced rapid vs. slow upsloping ST-segment depression
101. Exercise-induced minor vs. abnormal horizontal or downsloping ST-segment depression
102. Exercise-induced ST-segment elevation in non—infarct-related vs. 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, postrevascularization 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

This is a revision of the January 1995 document that was written by Harold L. Kennedy, MD, MPH, FACC – Chair; Ary L. Goldberger, MD, FACC; Thomas B. Graboys, MD, FACC; and E. William Hancock, MD, FACC.

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

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Background

Since the American College of Cardiology Core Cardiology Training Symposium (COCATS) guidelines were originally published (1), the discipline of both diagnostic and interventional cardiac catheterization has become increasingly complex. Advances in coronary revascularization techniques, including the increased use of intracoronary stents in patients undergoing percutaneous coronary intervention and the increased use of arterial conduits and minimal access approaches in patients undergoing coronary bypass surgery, have allowed the extension of these procedures to older patients with more extensive coronary and comorbid disease. New pharmacologic agents such as glycoprotein IIb/IIIa platelet receptor antagonists and low-molecular-weight heparin are being used in the treatment of acute coronary syndromes in patients in need of invasive coronary procedures. Enthusiasm for primary angioplasty in the treatment of acute myocardial infarction has resulted in an increase in the acuity of patients presenting to the cardiac catheterization laboratory. In addition, enhancements in cineangiographic systems and digital imaging in addition to expedited patient care have resulted in an increased number of revascularization procedures being performed at the time of diagnostic coronary angiography. These changes in practice have increased the cognitive and technical knowledge base required to be possessed by invasive cardiologists. Consequently, this document revises and updates the standards for training in invasive cardiology.

These developments have been recognized by the American Board of Internal Medicine (ABIM), which has developed an added qualification certifying examination, and by the Residency Review Committee of the American Council on Graduate Medical Education (ACGME), which has developed a formal accreditation mechanism for interventional cardiology training programs. The recommendations in this document are consistent with the requirements of ABIM and ACGME. In 1999, the American College of Cardiology 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 cardiac catheterization (Levels 1 and 2) must occur within a cardiology training program that is fully accredited by 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) is now limited to formal training programs. All interventional cardiology training programs in the United States must satisfy the basic standards developed by ACGME and must be accredited by ACGME for candidates to be eligible for the clinical interventional cardiology certificate of added qualification of the ABIM. This requirement becomes effective in July 2002. 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 communicate to the trainee the requisite cognitive and technical knowledge of invasive cardiology. The cardiac catheterization laboratory provides instruction in the core knowledge base of cardiac anatomy, physiology, pathology, and pathophysiology needed by all cardiologists. 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 three 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.

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 below. All cardiologists should have Level 1 knowledge and skills.

*American Council of Graduate Medical Education Representative

Program Structure

Faculty

Faculty should be full-time, experienced, and committed to the teaching program. Exposure to multiple faculty trainers 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 three key faculty members, one of whom is the program director and each of whom maintains a minimum procedural volume of 150 catheterization procedures per year and devotes at least 20 hours per week to the program. Associated faculty may have varying levels of commitment and involvement in the program.

Program Director

The program director 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 own training at least 5 years previously and will be a fully affiliated faculty member of the overall cardiovascular training program. This individual should be responsible for administration of the cardiac catheterization laboratory, the overall teaching program, quality control, and trainee evaluation.

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, transseptal catheterization, interpretation and preferably performance of intracoronary ultrasound, Doppler coronary flow, and intracoronary pressure measurement, although each member need not have expertise in every area. Faculty who are responsible for training in interventional cardiology should meet the requirements outlined in the previously published American College of Cardiology training statement (2).

Facilities and Environment

All training facilities must be equipped and staffed to function in accordance with the American College of Cardiology/ Society for Cardiac Angiography and Interventions clinical expert consensus document on cardiac catheterization laboratory standards (3).

X-Ray Imaging Equipment

The cardiac catheterization laboratory must generate high-quality X-ray images during diagnostic and interventional catheterization procedures. Digital radiographic image acquisition is preferable. 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. Laboratories that perform interventional procedures must be equipped with digital-image road map capability.

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 intracoronary ultrasound, although not mandatory, 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, 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 vascular 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. Only one Level 1 trainee may claim credit for participation in a given procedure.

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. Only one Level 2 trainee may claim credit for participation in a given procedure.

Level 3

Level 3 training must be performed during a fourth year of fellowship dedicated primarily to coronary interventional training (2). During this period, the trainee should participate in a minimum of 250 coronary interventional procedures.

Table 1. Summary of Training Requirements for Diagnostic and Interventional Cardiac Catheterization

Level	Duration of Training, mo	Cumulative Duration of Training, mo	Minimum No. of Procedures		Cumulative No. of Examinations	
			Diagnostic	Interventional	Diagnostic	Interventional
1	4	4	100	0	100	0
2	4	8	200	0	300	0
3	12	20	0	250	300	250

*Only one Level 1, 2, or 3 trainee may claim credit for a procedure. See text for explanation.

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. *Preprocedural evaluation to assess appropriateness and to plan procedure strategy.* Before the procedure, the trainee should review the medical chart 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, and conditions known to increase the risk of bleeding. The trainee should also obtain informed consent and write a preprocedural 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 an 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. *Active involvement in postprocedural 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 chart. 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 postprocedural 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

The trainee should possess the cognitive knowledge and technical skills detailed below.

Knowledge Base

Level 1 Cognitive Knowledge

1. Understand the indications for cardiac catheterization
2. Understand coronary anatomy, its variations, and congenital abnormalities
3. Understand coronary physiology
4. Understand the complications of the procedure and their management, such as hypotension, acute myocardial ischemia, congestive heart failure, renal failure, vascular complications, contrast reactions, retroperitoneal bleeding, and cardiac tamponade
5. Select the optimal treatment modality, including medical therapy, percutaneous coronary intervention, or surgical therapy, with understanding of the indications for and risks of each revascularization strategy
6. Understand cardiac hemodynamics, including the measurement and interpretation of pressure, flow, resistance, and cardiac output
7. Interpret hemodynamic findings in a variety of cardiac conditions, including various forms of myocardial disease, pericardial disease, valvular stenosis and regurgitation, congenital heart disease, and pulmonary vascular disease
8. Understand the indications for and complications of temporary transvenous pacing
9. Understand the indications for and complications of pericardiocentesis and recognize tamponade physiology
10. Understand the indications for and complications of other laboratory procedures, such as endomyocardial biopsy, intra-aortic balloon counterpulsation, and retrieval of foreign bodies
11. Understand basic principles of X-ray imaging, radiation protection, and radiation safety
12. Understand the anatomy of and methods to access cardiac chambers and coronary arteries via the femoral, brachial, and radial access sites
13. Interpret coronary, ventricular, atrial, and aortic angiography and determine left ventricular ejection fraction

14. Understand the indications for and complications of contrast agents and drugs commonly used for invasive procedures, such as heparin, low-molecular-weight heparin, glycoprotein IIb/IIIa receptor antagonists, other antiplatelet drugs, thrombolytic drugs, vasopressors, vasodilators, and antiarrhythmic drugs

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) 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 how to differentiate the hemodynamics of constrictive pericarditis from restrictive cardiomyopathy
5. Understand coronary physiology using techniques such as Doppler flow and fractional flow reserve
6. Understand the indications for and methods of performing transseptal catheterization
7. Understand the indications for and complications of vascular closure devices

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 artery grafts
4. Perform angiography of the cardiac chambers 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
8. Perform vascular closure device insertion

Level 3 Cognitive Knowledge and Technical Skills

The trainee should possess the cognitive knowledge and technical skills outlined in the previously published American College of Cardiology training statement (2).

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. 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).

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 three components: cognitive, technical, and documentary. Case selection and preprocedural, intraprocedural, and postprocedural care and judgment must be evaluated in every trainee. Facilities that foster the ability of the trainee to be in involved in the continuum of care (outpatient or inpatient) from preprocedural assessment to postprocedural 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 evaluated. 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 is responsible for 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 during the training period is vital to direct the trainee's progress.

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Task Force 4: Training in Echocardiography

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Echocardiography is currently the most widely used imaging technique for assessing cardiovascular anatomy and function. Clinical application of ultrasound encompasses M-mode, two-dimensional, 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 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. At all levels of training, trainees should be required to perform the echocardiographic and Doppler examination to integrate their understanding of three-dimensional 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 bioengineering 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 two-dimensional echocardiographic/Doppler technology and its multiple clinical applications. It is recognized that ultrasound 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 three 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, two-dimensional, 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 (TEE) and stress echocardiography can be undertaken as described later in this report. 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 three levels differ and are addressed separately.

General Standards

Training in echocardiography should be integrated closely with the educational experience in cardiovascular catheterization and intervention, surgery, and pathology. The echocar-

Table 1. Summary of Training Requirements for Echocardiography

Level	Duration of Training, mo	Cumulative Duration of Training, mo	Minimal (Total) No. of TTE Examinations Performed	Minimal (Total) No. of TTE Examinations Interpreted	TEE and Special Procedures
1	3	3	75	150	Yes*
2	3	6	150 (75 additional)	300 (150 additional)	Yes†
3	6	12	300 (150 additional)	750 (450 additional)	Yes

TEE indicates transesophageal echocardiography; TTE, transthoracic echocardiography.
*Initial 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.

*American Council of Graduate Medical Education Representative

diographic 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 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-time or part-time faculty is highly desirable because of the multiple applications of echocardiography (i.e., transesophageal, stress, contrast, intraoperative, intravascular, 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 three-dimensional framework, and understand the distinction between reliable and unreliable data. The trainee should develop sufficient technical facility to use an echocardiographic instrument to answer common clinical questions. To help with this training, availability of highly skilled cardiac sonographers with broad experience in the performance of the echocardiographic examination is desirable.

Content of the Training Program

Echocardiography plays an important role in the diagnosis and treatment of a wide variety of acquired and congenital cardiac disorders in a diverse group of patients. Accordingly, it is highly desirable that any laboratory in which cardiology fellows undertake echocardiographic training provide exposure to the entire spectrum of acquired and congenital heart diseases in patients of varying ages and both sexes (6,7). Generally, such a laboratory should conform to continuing quality improvement guidelines (8) 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 criteria described herein are similar to those in other publications on this topic (1,2,9-12). 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 (13). 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 transthoracic and transesophageal echocardiography, including M-mode and two-dimensional imaging, pulsed and continuous-wave Doppler echocardiography, and color flow imaging. These capabilities may be contained in a single device or in multiple instruments.

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.

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

The first, or introductory, level requires 3 months of full-time training or its equivalent devoted to an understanding of functional anatomy and physiology in relation to the echocardiographic examination. During this time, the trainee should participate in the interpretation of a minimum of 150 complete (M-mode, two-dimensional, 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 and Interpretation of 150 Additional Examinations, of Which 75 Should Be Personally Performed)

During Level 2 training, emphasis should be placed on the intensity, 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 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 transthoracic echocardiographic examination accurately and independently. Continued exposure to special echocardiographic procedures such as TEE 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 (Additional 6 Months of Training, 450 Additional Examinations)

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, including performance of an additional 150 studies) 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 transesophageal, stress, and contrast echocardiography.

Training for Physicians in Practice

It should be recognized how difficult it is to recreate the breadth and intensity of a training fellowship once an individual has assumed the full-time responsibilities of a practice setting. It may be possible to obtain the equivalence of Level 1 or 2 training outside the usual fellowship track through 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

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, or mitral balloon valvulotomy), and transthoracic echocardiography 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 below. 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 (14-16), 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 (8,9). Specific recommendations for the various procedures follow.

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 (9). 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.

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 (14,15). 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 TEE

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. 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. Intraoperative echocardiography is an area in which diagnostic conclusions have the potential for immediate major changes in patient management. Specific numbers for training are not available from previous documents (16-18). However, it is recommended that the cardiology trainee should complete at least Level 2 training in echocardiography and have performed, interpreted, and reported at least 150 complete intraoperative studies for independent diagnostic expertise in this field. 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 (17).

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 anticipated that this skill would be introduced 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.

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.

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Task Force 5: Training in Nuclear Cardiology

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The recommendations of this Joint Task Force, made up of representatives of the American College of Cardiology (ACC) and the American Society of Nuclear Cardiology (ASNC), have been approved by the governing bodies of both the ACC (on February 18, 2000) and the ASNC (on March 14, 2000). This section was prereleased on the Web sites of the ACC and ASNC in July 2000.

Training in Nuclear Cardiology

Nuclear cardiology (Table 1) provides important diagnostic and prognostic information that is an essential part of the knowledge base required by 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.[1]
- Advanced (Level 3, 1 year): Provides advanced training sufficient to pursue an academic career or direct a nuclear cardiology laboratory.[1]

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 for 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 a program is not available as part of the clinical ACGME training program.

Nuclear cardiology training consists of the components shown in Table 2. Didactic, clinical case experience and hands-on training hours require documentation in a logbook, 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 pro-

*American Society of Nuclear Cardiology Representative

†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 ACC 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 9929 Main Street, Suite C, Damascus, Maryland 20872, http://www.cbnc.org.

[1]Level 2 and Level 3 training meet eligibility criteria for taking the Certification Board of Nuclear Cardiology examination and 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 31 states that have applied and been approved by the NRC to self-regulate the use of radioactive materials, so called "Agreement States." The other 19 states 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 maybe 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.hsrd.ornl.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 you with information on contacting the individual states and getting the specific licensure requirements.

Table 1. Classification of Nuclear Cardiology Procedures

1. Standard nuclear cardiology procedures
a. Myocardial perfusion imaging
i. Single photon emission computed tomography (SPECT) with technetium agents and thallium
ii. Planar with technetium agents and thallium
iii. Electrocardiographic (ECG) gating of perfusion images for assessment of global and regional ventricular function
iv. Imaging protocols
v. Stress protocols
1. Exercise stress
2. Pharmacologic stress
vi. Viability assessment including reinjection and delayed imaging of thallium and metabolic imaging where available
b. Equilibrium gated blood pool or "first pass" radionuclide angiography at rest and during exercise or pharmacologic stress
c. Qualitative and quantitative methods of image display and analysis
2. Less commonly used nuclear cardiology procedures
a. Metabolic imaging using single photon and/or positron emitting radionuclides
b. Myocardial infarct imaging
c. Cardiac shunt studies

cedure, or both. The preceptor for specialized or advanced training should have Level 3 (or the equivalent) training in nuclear cardiology.

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

Didactic Program

Lectures and Self-Study

This component is composed of lectures on the basic aspects of nuclear cardiology and parallel self-study material consisting of reading and viewing cases on video or CD. The lectures and reading should provide the fellow with an understanding of the clinical applications of nuclear cardiology, including imaging with positron emitting radionuclides. The material covered should include radiopharmaceuticals, 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. Fellows seeking Level 2 or Level 3 training will require greater in-depth knowledge as well as hands-on practical experience. These are detailed for each level.

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 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/cardiac catheterization 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 pretest patient evaluation; radiopharmaceutical preparation—measuring the dose, administration and experience with relevant radionuclide generators; operation and quality control of planar and SPECT gamma camera 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 for performing diagnostic nuclear cardiology 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 two-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 three 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.

Interpretation of Nuclear Cardiology Studies

During the 2-month rotation, fellows should actively participate in daily nuclear cardiology study interpretation (minimum of 80 h). 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. This includes a minimum of 700 h of didactic, clinical study interpretation and hands-on clinical case and radiation safety training in nuclear cardiology. 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 and qualify them to become authorized users of radioactive materials in accordance with the regulations of the Nuclear Regulatory Commission (NRC) and/or the Agreement States (1).

Didactic Program

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 need to include extensive review of radiation physics, radiation protection, mathematics pertaining to the use and measurement of radioactivity, chemistry of byproduct material for medical use, radiation biology and radiopharmaceuticals. There should be a thorough review of regulations dealing with radiation safety for the use of radiopharmaceuticals.

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/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 an experience. A total of 300 cases should be interpreted under preceptor supervision, either from direct patient studies or from a teaching file consisting of diverse types of procedures (Table 1).

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 pretest patient evaluation, radiopharmaceutical preparation (including experience with relevant radionuclide generators), performance of the study, administration of the dosage, calibration and setup of the gamma camera, setup of

the imaging computer, processing the data for display, interpretation of the studies and generating clinical reports.

Radiation Safety

This experience should be under the supervision of an authorized user who meets the NRC requirements of Part 35.290 or Part 35.390 or the equivalent Agreement State requirements, and should include:

a. Ordering, receiving and unpacking radioactive materials safely and performing the related radiation surveys;
b. Calibrating 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 myocardial perfusion imaging, ECG gated perfusion studies, gated equilibrium studies, “first-pass” and any of the less commonly performed procedures available at the institution
- Quantitative analysis of perfusion and/or metabolic studies
- Quantitative radionuclide angiographic and gated perfusion analyses, including measurement of global and regional ventricular function
- SPECT perfusion acquisition, reconstruction and display
- ECG-gated SPECT perfusion acquisition, analysis and display of functional data
- Imaging of positron emitting tracers using either dedicated positron emission tomography (PET) systems or SPECT-like systems equipped with either high photon energy collimators or coincidence detection

The requirements for Level 1–3 training in nuclear cardiology are summarized in Table 3.

Table 3. Summary of Training Requirement for Nuclear Cardiology

Level	Minimum Duration of Training, mo	Total Number of Examinations
1	2	80 h interpretative experience
2	4 to 6	300*
3	12	600*

*A minimum of 35 cases with hands-on experience must be performed and interpreted under supervision. The remaining supervised interpretative experience can be obtained from a teaching file.

Specific Training in Cardiac Imaging of Positron Emitting Radionuclides

Cardiac PET and imaging of positron emitting radionuclides is part of nuclear cardiology but technically different and not widely available. Nevertheless, at this time, 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 imaging of positron emitters, 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 or positron imaging 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 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 positron 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. 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 or 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 tracer kinetic models, cardiac innervation and receptors, and methods for quantifying regional myocardial blood flow and substrate metabolism

2. Imaging instrumentation including dedicated PET 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 reconstruction, 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.

This is a revision of the January 1995 document that was written by James L. Ritchie, MD, FACC – Chair; Lynne L. Johnson, MD, FACC; Jamshid Maddahi, MD, FACC; Heinrich R. Schelbert, MD, PhD, FACC; Frans J. Th. Wackers, MD, FACC; and Barry L. Zaret, MD, FACC.

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

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Clinical cardiac electrophysiology and cardiac pacing have matured significantly and are merging into a common cardiac subspecialty discipline. Today, complex cardiac arrhythmias are managed by cardiologists and cardiac surgeons with special expertise in cardiac electrophysiology, the use of implantable pacemakers and cardioverter-defibrillators, and the application of other interventional techniques and treatments. Nonpharmacologic therapy also includes electrophysiologic mapping and subsequent catheter or surgical ablation as standard treatment for certain tachyarrhythmias. Many new antiarrhythmic agents with diverse mechanisms of action are often used therapeutically alone or in conjunction with implantable multiprogrammable arrhythmia control devices (pacemakers and implantable cardioverter-defibrillators [ICDs]).

In 1986, a Task Force 6 report on training in cardiac pacing (1) was published as a result of Bethesda Conference 17 on adult cardiology training. In 1991, a training statement recommending guidelines for training in adult clinical cardiac electrophysiology was published (2). In 1995, a task force (3) combined these two closely related disciplines to reflect the current merging of science, art, and the practice of clinical cardiac electrophysiology. The present task force updated recommendations on the basis of changes in electrophysiology, cardiac pacing, and arrhythmia management that have occurred over the last 5 years.

General Standards and Environment

Facilities and Faculty

Three organizations—the American College of Cardiology (ACC), the American Heart Association (AHA), and the North American Society of Pacing and Electrophysiology (NASPE)—have addressed training requirements and guidelines for temporary (4) and permanent (5) pacemaker selection, implantation, and follow-up (6); guidelines for the use of ICDs in cardiovascular practice (5,7,8); guidelines for training in catheter ablation procedures (9,10); training requirements for permanent pacemaker selection, implantation, and follow-up (7); and teaching objectives for fellowship programs in clinical electrophysiology (11,12). The training recommendations for these three organizations are congruent and address new technologies, faculty, and facility requirements, as well as practice standards.

It is strongly recommended that 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 clinical cardiac electrophysiology 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. The faculty may be heterogeneous; however, at least one faculty member must be board certified by the ABIM in clinical cardiac electrophysiology (or its equivalent), and the same or another faculty member must be recognized as an expert in pacing for accrediting advanced levels of training in each respective area.

Levels of Training

Level 1

Within the cardiology core training program, Level 1 should comprise at least 2 months of clinical cardiac electrophysiology rotation designed for cardiology trainees to acquire knowledge and experience in the diagnosis and management of bradyarrhythmias and tachyarrhythmias. Every cardiology trainee should learn the indications for and limitations of electrophysiologic studies, the appropriate use of pharmacologic and nonpharmacologic therapeutic options, and the proper and appropriate use of antiarrhythmic agents, including drug interactions and proarrhythmic potential.

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

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electrocardiographic (ECG) monitoring, event recorders, exercise testing for arrhythmia assessment, tilt-table testing, signal-averaged electrocardiography, invasive electrophysiologic testing, and implantation of cardiac arrhythmia control devices. These requirements are in addition to the basic ECG training addressed by Task Force 2 and thus necessitate an additional minimum of 2 months.

Electrocardiographic manifestations of arrhythmias should be taught on a regular basis during formal 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, cardiac and noncardiac surgical patients, and the precardiac transplantation and postcardiac transplantation patient 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, knowing indications for temporary and permanent pacing and the implantation of ICDs (5), knowing pacing modes, and understanding basic techniques for interrogation, programming, and surveillance of pacemakers and ICDs.

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 electrograms for management of patients with temporary pacemakers; and indications and techniques for elective and emergency cardioversions (15). Insertion of a minimum of 10 temporary pacemakers and performance of at least 10 elective cardioversions are required. These experiences can be obtained throughout the 24-month clinical training period.

Level 2

Some trainees in cardiology may wish to acquire advanced training in management of arrhythmias but not undertake training in all aspects of cardiac electrophysiology. Such training, referred to here as Level 2 training, would be appropriate for individuals who wish to have careers with a substantial proportion of their time spent as a heart station or ECG laboratory director or in a pacemaker or ICD follow-up or syncope evaluation service.

All candidates for Level 2 training must meet all training requirements under Level 1. 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.

Level 2 trainees should meet all Level 1 requirements and should obtain advanced training in normal and abnormal cardiac electrophysiology and mechanisms of arrhythmias. In addition, proficiency in the performance and interpretation of noninvasive diagnostic procedures (ambulatory ECG monitoring, event recording, telephone ECG transmission, signal-averaged electrocardiography, tilt-table testing, heart rate variability, and other tests of the autonomic nervous system) should be acquired. 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 systems and ICDs. 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 expertise in temporary pacing, transesophageal atrial pacing, cardioversion, interpretation of invasive electrophysiologic study data, and complex arrhythmia ECG 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 will 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 (clinical cardiac electrophysiology) (16). Requirements of Levels 1 and 2 must be fully met.

Clinical cardiac electrophysiology training will include 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 elective time in electrophysiology. A dedicated fourth year of training in clinical cardiac electrophysiology after 3 years is required. The appropriate use, safe performance, and judicious interpretation of these complex procedures requires highly specialized training and competence and cannot be accomplished in a 3-year training program. Furthermore, an advanced knowledge base in basic clinical cardiac electrophysiology 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 as the primary operator or as an assistant involved with the acquisition and analysis of the data. Electrophysiologic procedures should cover the total spectrum of arrhythmias, both supraventricular and ventricular tachyarrhythmias as well as bradyarrhythmias. At least 75 of these procedures should be with patients with supraventricu-

lar tachyarrhythmias. It is recognized that these numbers represent minimum training requirements for a cardiac electrophysiologist. Trainees who wish to become skilled in some of the more complex electrophysiology procedures, e.g., ablation for atrial fibrillation or evaluation of patients with congenital heart disease, would benefit from a longer period of training or posttraining 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 at least 15 cases of left heart mapping by the retrograde aortic approach. Training in transseptal catheterization should be provided by an individual at the training institution with expertise in the technique. Experience with at least 10 transseptal 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. The trainee 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. This experience will include at least 50 device evaluations (combined implantation and follow-up). Although the Level 3 trainee must have significant exposure to the management and follow-up of ICD pacemaker implantation, he or she will not necessarily be trained in the surgical aspects of these procedures (Table 1).

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. This device 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 bradycardia device implantation (pacemakers), previous or concurrent Level 2 training is required. The pacemaker implantation training must include development of expertise in permanent atrial and ventricular lead placement, threshold testing and programming of devices, principles of surgical asepsis, surgical techniques of implantation, and management of implant-related complications. Individuals receiving qualifying training in pacemaker implantation must participate as the primary operator (under direct supervision) in at least 50 primary implantations of transvenous pacemakers and 20 pacemaker system revisions or replacements. At least half of the implantations should involve dual-chamber pacemakers. The trainee must also participate in the follow-up of at least 100 pacemaker patient visits and acquire proficiency in advanced pacemaker electrocardiography, interrogation, and programming of complex pacemakers. 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

Table 1. Summary of Training Requirements for Electrophysiology, Cardiac Pacing, and Arrhythmia Management

Level	Curriculum Skills	Time Requirement (Cumulative)	Cumulative Number of Examinations	Special Procedures
1	Cardiac arrhythmia and electrophysiology core	2 Months (in addition to Task Force 2 ECG training requirements)	10 Temporary pacemakers; 8 cardioversions	Temporary pacemakers; cardioversions
2	Advanced noninvasive arrhythmology	6 Months	100 Pacer/ICD interrogations	Pacer/ICD interrogation
3	Device implantation	12 Months	50 Pacer implants; 25 ICD implants; 100 pacer/ICD interrogations	Pacer/ICD implantation and interrogation
3	Invasive EP, ablation	12 Months (beyond 3-year cardiology training is required to meet ABIM CCEP examination requirements)	150 EP procedures; 75 ablation procedures	Invasion EP ablation
3	Device implantation, invasive EP, ablation	24 Months	Same as level 3 device implantation, invasive EP, ablation	Invasive EP ablation; pacer/ICD implantation and interrogation

ABIM = American Board of Internal Medicine; CCEP = Clinical Cardiac Electrophysiology; EP = electrophysiology; and ICD = implantable cardioverter-defibrillator.

pacemakers, exposure to the indications, implantation techniques, and follow-up of loop recorders is desirable.

The trainee pursuing a career in cardiac electrophysiology 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 (16). 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. Pacemaker lead extraction is a specialized procedure that requires special training but is not an obligate part of training for CCEP examination eligibility.

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-ICD and pacemaker-ICD interactions; and a thorough knowledge of ICD programming and management of ICD malfunction and postoperative complications. The trainee must also participate in the surgical replacement or revision of at least 10 ICD systems and follow-up of at least 50 ICD patient visits. Level 3 training with the option of pacemaker or ICD implantation or both requires a minimum of 1 year of dedicated clinical cardiac electrophysiology and device implantation training beyond the 3-year cardiology program.

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 and AHA (in collaboration with NASPE) have formulated a clinical competence statement on invasive electrophysiology studies, catheter ablation, and cardioversion (17). Self-assessment programs are available through the ACC. Competence examinations in electrocardiography are administered by the Institute for Clinical Evaluation. Training directors and trainees are encouraged to utilize these resources.

The ACGME has recently published the essential components of a specialized program for training in clinical cardiac electrophysiology. The ABIM provides a special examination for additional certification in clinical cardiac electrophysiology. Information concerning the training requirements for admission to the examination can be obtained from the ABIM; such requirements include an additional year of training in an ACGME-accredited electrophysiology program. NASPE also has a written examination of special competence in device therapy, but it does not provide certification (18). 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.

This is a revision of the January 1995 document that was written by Mark E. Josephson, MD, FACC – Co-Chair; James D. Maloney, MD, FACC – Co-Chair; S. Sege Barold, MD, FACC; Nancy C. Flowers, MD, FACC; Nora F. Goldschlager, MD, FACC; David L. Hayes, MD, FACC; and Eric Prystowsky, MD, FACC.

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Task Force 7: Training in Cardiovascular Research

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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 epidemiologic 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

Individual trainees should have, before their appointment, appropriate preparation in the biologic, epidemiologic, 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 one 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.

Table 1. Duration of Research Training

Level	Training Population	Duration of Training
1	Trainees entering clinical practice	6 to 12 months
2	Trainees committed to teaching and clinical investigation	Minimum of 2 years
3	Trainees committed to basic or clinically advanced cardiovascular research	2 to 3 years

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, 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

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) risk/benefit and societal risk/benefit

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 does not require a dedicated block of time. For those planning a substantive commitment to teaching and clinical investigation (Level 2), a minimum of 1 full year (e.g., 100% of time for 1 year or 50% of time for 2 years) should be devoted to clinical research.

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 postdoctoral research fellowship experience or as part of the cardiology traineeship. For full-time training, the trainee should enter the group or laboratory of a productive and active scientist, or clinical investigators (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 and K23 awards, clinical scientists, and physician scientists (Clinical Investigator Development Award [CIDA]).

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 also useful to provide opportunities for the critical review and analysis of published manuscripts.

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 January 1995 document that was written by Edmund H. Sonnenblick, MD, FACC – Chair; Thomas J. Ryan, MD, FACC; and Rodman D. Starke, MD, FACC.

Task Force 8: Training in Heart Failure and Transplantation

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The treatment of heart failure has long been considered the "bread and butter" of clinical cardiology, and the subject of transplantation has been considered one of the more esoteric offshoots of the field. However, in the 1990s, advances in both fields have led to increasingly specialized and sophisticated therapy for heart failure at the same time that the application of transplantation for end-stage heart disease has become widely accepted and practiced. Thus, it now seems appropriate to include specific training in both areas in programs that train consultants in cardiovascular medicine and to describe advanced training for those who wish to devote a substantial part of their career to this field.

Training in Heart Failure

Level 1: General Training

The fundamental concepts involved in the physiology of congestive heart failure and its treatment should be well understood by all trainees in cardiovascular medicine as part of the core curriculum. Training in clinical management of heart failure should include supervised experience in both inpatient and outpatient settings and should involve a spectrum of underlying causes of heart failure. Trainees should be well acquainted with the nuances of therapy of heart failure that are particular to different underlying causes and should be conversant with the pharmacology of the standard cardiovascular drugs used to treat heart failure. Trainees should also be equally aware of the treatment strategies for patients with both chronic disease and acute exacerbations. Such training should optimally occur in the context of a dedicated heart failure or heart failure/transplant clinical service that combines inpatient and outpatient evaluation and management. Rotation on this service will be incorporated during the trainee's clinical nonlaboratory experience and should comprise a minimum of 1 month, either as a stand-alone rotation or incorporated in the nonlaboratory months of training in programs with no separate heart failure service. Faculty members with specialized expertise in heart failure management should have a strong role in supervising training in this area.

Level 2: Specialized Training

Trainees who wish to have more advanced training in heart failure should be enrolled in programs that include specific clinics and inpatient services for patients requiring therapy for advanced heart failure as described for Level 1. However, such programs should also offer a broad spectrum of modalities for heart failure therapy, such as cardiac transplantation and other surgical approaches or mechanical circulatory support. Trainees attaining Level 2 training should actively participate in didactic activities relating to heart failure, including research conferences, seminars, and journal clubs with heart failure as a focus. Trainees at institutions without a transplantation program may obtain such training through rotations at other hospitals. Trainees should be well versed in interpretation of hemodynamic data during both acute and chronic interventions and in assessment of prognosis, as well as in the nature and status of major and ongoing advances in the field. Specialized training should encompass a total of 6 months.

Level 3: Advanced Training

For trainees who wish to pursue a career in heart failure or heart failure/transplantation, an extended program is required. Such a program should include specific clinics and inpatient services for patients requiring therapy for advanced heart failure as described above for Levels 1 and 2. The program should also include the following:

1. A broad spectrum of modalities for heart failure therapy, such as cardiac transplantation, other surgical approaches, and mechanical circulatory support
2. Research efforts focused on the use of new or experimental treatment modalities—both drugs and devices—as well as transplantation
3. Concurrent active participation in laboratory and clinical research and individual responsibility for research efforts.

The trainee should participate in such activities for a 12-month period beyond basic cardiovascular training. Training in heart failure and transplantation may occur concurrently.

Training in Cardiac Transplantation

Level 1: General Training

It is recognized that not all centers with training programs in cardiovascular medicine also have active programs in cardiac or cardiopulmonary transplantation. Thus, it will not be possible (and probably not desirable) for all cardiovascular trainees to have hands-on experience with the management of heart transplant recipients. With the large number of heart transplants performed annually (currently approximately 2500 in the United States) and the excellent survival rates (80 to 90% at 1 year) (1), a rapidly increasing number of long-

*Heart Failure Society of America Representative

term transplant recipients requiring sophisticated care are accruing, and cardiovascular specialists can expect to be called on to participate in their care. It is important, therefore, that training in any program include both didactic and practical experience with the role of transplantation in the management of various types of end-stage heart disease and with the thoughtful selection and referral of such patients for transplantation procedures. Trainees should also have a basic understanding of a number of transplant-related issues, including the following:

1. Overall success rates and survival rates to be expected
2. Current indications, as well as absolute and relative contraindications, to cardiac transplantation
3. The atypical physiology of the denervated heart and abnormal responses to some cardiac medications
4. The major types of long-term complications to be anticipated, especially allograft coronary artery disease and complications due to immunosuppression.

Level 2: Advanced Training

For trainees who wish to devote a substantial portion of their career to transplant-related research and patient management, further training beyond other clinical requirements for cardiology training should be required. Although there are currently very few formal training programs in transplant cardiology, a number of centers do provide such training, and an outline of the important aspects can be drawn. Formal criteria for certification of a cardiac transplant physician from the bylaws of the United Network for Organ Sharing (UNOS), the US organ procurement and transplantation network, are included in the Appendix.

Training Resources and Faculty

Training should be obtained at a center that has an established program in clinical cardiac transplantation and a reasonable volume of transplant procedures, preferably greater than 20 procedures per year, to qualify for UNOS certification, as noted below. The training program should be staffed by 1 or more board-certified cardiologists with recognized training and expertise in and commitment to cardiac transplantation. The program will, of necessity, also be staffed by one or more board-certified cardiovascular surgeons and will usually encompass a training program in transplant surgery as well. Centers with such programs will also require the availability of highly qualified consultants in infectious disease, nephrology, and pulmonary medicine and will have periodic meetings and conferences devoted to cardiac transplantation. This period of advanced training will usually be simultaneous with advanced training in heart failure as outlined above and may occur during the trainee's period of regular cardiology training; such training would satisfy minimum UNOS criteria. However, most programs offering such advanced training should require participation for a 12-month period beyond basic cardiovascular training, and in most programs, this experience will be concomitant with advanced training in heart failure, as outlined above.

Training Experience

The advanced trainee in cardiac transplantation should spend 1 year involved in all phases of pretransplant and posttransplant clinical management and will usually participate in laboratory or clinical transplant-related research as well. He or she should have hands-on experience with the care of acute and chronic heart failure, recipient selection, postoperative immunosuppressive management, histologic interpretation of myocardial biopsies for rejection, and long-term outpatient follow-up. The trainee should have acquired a working knowledge of donor selection, the use of mechanical assist devices, methods of organ procurement and preservation, and transplant surgical procedures and perioperative management. He or she should be competent in the performance of right ventricular endomyocardial biopsies in addition to the more standard invasive procedures learned earlier in training. Such training will qualify the cardiologist under current UNOS guidelines as a cardiac transplant physician.

Evaluation of Trainees

Evaluation by the program director and faculty should be an integral part of the educational process, and procedures for regular evaluation of clinical competence and research progress should be established in each program. There should also be provisions for regular feedback on this evaluation to the trainee and for the keeping of records of these evaluations. There are currently no types of formal examination or certification for the added qualification in heart failure and transplantation. It is the responsibility of the program director to confirm and document the individual's competence and thoroughness of training. The director should be prepared to certify specifics of the training experiences to UNOS (and other organizations in the future) that require them for program certification.

Table 1. Summary of Training Requirements for Heart Failure and Transplantation

Level	Duration of Training, mo	Exposure to Transplant/Other Surgical Approaches, mo	Participation in Research Activity, mo
1	1	—	—
2	6	6	—
3	12	12	12

*Appendix: Criteria for Cardiac Transplant Physicians**

(4) Heart Transplantation

(b) Transplant Physician—Each thoracic organ transplant program must have on site a qualified transplant physician. A transplant physician for a thoracic organ shall be a physician with an M.D. or D.O. degree or equivalent degree from another country who is licensed to practice medicine in his/her state or political jurisdiction and has been accepted onto the medical staff of the applicant hospital. If an individual is certified by the American Board and its foreign equivalent, the individual must maintain currency in the American Board.

The cardiac transplant physician will have and shall maintain current board certification or have achieved eligibility in adult or pediatric cardiology or the subspecialty of his/her major area of interest by the American Board of Internal Medicine or American Board of Pediatrics or their foreign equivalent. The individual shall provide a letter from the applicant hospital's credentialing committee stating that the physician continues to meet all requirements to be in good standing.

To qualify as a heart transplant physician, the training/experience requirement will be met if the following conditions of either (aa), (bb), (cc), (dd), (ee), (ff), or (gg) are met:

(aa) Training/experience during the applicant's cardiology fellowship.

(i) That the individual will have been involved in the primary care of 20 or more heart or heart/lung transplant recipients from the time of their transplant. This training will have been under the direct supervision of a qualified cardiac transplant physician and in conjunction with a cardiac transplant surgeon at a UNOS approved cardiac transplant center that conducts 20 or more heart or heart/lung transplants each year. This application must be supported by a recipient log. Such a log should include at least the medical record and/or UNOS identification number and the date of transplant.

(ii) That the individual has been involved with and has a current working knowledge of cardiac transplantation, including the care of acute and chronic heart failure, donor selection, use of mechanical assist devices, recipient selection, pre and post-operative hemodynamic care, post-operative immunosuppressive therapy, histologic interpretation and grading of myocardial biopsies for rejection, and long-term outpatient follow-up.

(iii) The individual should participate as an observer in 3 organ procurements and subsequent transplants. In addition the individual should observe the selection and management of at least 3 multiple organ donors which include the heart and/or heart/lung. These cases must be documented. Documentation should include the date of procurement, medical record and/or UNOS identification number, and location of the donor.

(iv) That the above training be in addition to other clinical requirements for cardiology training.

(v) That the individual has a letter sent directly to UNOS from the director of the individual fellowship training program as well as the supervising qualified cardiac transplant physician verifying the fellow has met the above requirements and that he or she has qualified to become a medical director of a cardiac transplant program.

(vi) That the individual has written a detailed letter to UNOS outlining his/her training and experience in a UNOS approved heart transplant program(s) or its foreign equivalent.

(vii) That the above training be performed at a hospital with an American Board of Internal Medicine certified fellowship training program in adult cardiology and/or American Board of Pediatrics certified fellowship training program in pediatric cardiology.

(bb) When the training/experience requirements for the cardiac transplant physician have not been met during a cardiology fellowship, they can be met during a separate 12-month transplant medicine fellowship if all of the following conditions are met, and the individual is a board certified or eligible cardiologist.

(i) That the individual will have been involved in the primary care of 20 or more heart or heart/lung transplant recipients from the time of transplant. This training will have been under the direct supervision of a qualified cardiac transplant physician and in conjunction with a cardiac transplant surgeon. This application must be supported by a recipient log. Such a log should include at least the medical record and/or UNOS identification number and the date of transplant.

(ii) That the individual has been involved with and has a current working knowledge of cardiac transplantation, including the area of acute and chronic heart failure, donor selection, use of mechanical assist devices, recipient selection, pre and post-operative hemodynamic care, post-operative immunosuppressive therapy, histologic interpretation in grading of myocardial biopsies for rejection, and long-term outpatient follow-up.

(iii) The individual should participate as an observer in 3 organ procurements and subsequent trans-

*From UNOS By-Laws, Appendix B, Section III-4-b, 2000. Available at: www.unos.org.

plants. In addition the individual should observe the selection and management of 3 multiple organ donors which include the heart and/or heart/lung. These cases must be documented. Documentation should include the date of procurement, medical record and/or UNOS identification number, and location of the donor.

(iv) That the individual has a letter sent directly to UNOS from the director of the individual fellowship training program as well as the supervising qualified cardiac transplant physician verifying that the fellow has met the above requirements and that he or she has qualified to become a medical director of a cardiac transplant program.

(v) That the above training be performed at a hospital with an American Board of Internal Medicine certified fellowship training program in adult cardiology and/or American Board of Pediatrics certified fellowship training program in pediatric cardiology.

(vi) That the individual has written a detailed letter to UNOS outlining his/her training and experience in a UNOS approved heart transplant program(s) or its foreign equivalent.

(cc) If the cardiologist has not met the above requirements in a cardiology fellowship or specific cardiac transplant fellowship, the requirements can be met by acquired clinical experience if the following conditions are met, and the individual is a board certified cardiologist.

(i) That the acquired clinical experience is equal to two years on an active heart transplant service as the heart transplant physician or under the direct supervision of a qualified heart transplant physician and in conjunction with a heart transplant surgeon at a UNOS approved heart transplant center.

(ii) The individual will have been involved in the primary care of 20 or more heart or heart/lung transplant recipients from the time of their transplant. This experience will have been as the cardiac transplant physician or under the direct supervision of a qualified cardiac transplant physician or in conjunction with a cardiac transplant surgeon. The individual must have followed these patients for a minimum of 3 months post transplant. This application must be supported by a recipient log. Such a log should include at least the medical record and/or UNOS identification number and the date of transplant.

(iii) That the individual has been involved with and has a current working knowledge of cardiac transplantation, including the care of acute and chronic heart failure, donor selection, use of mechanical assist devices, recipient selection, pre- and post-operative hemodynamic care, post-operative immunosuppressive therapy, histologic interpretation and grading of myocardial biopsies for rejection, and long-term outpatient follow-up.

(iv) The individual should participate as an observer in 3 organ procurements and subsequent transplants. In addition the individual should observe the selection and management of 3 multiple organ donors which include the heart and/or heart/lung. These cases must be documented. Documentation should include the date of procurement, medical record and/or UNOS identification number, and location of the donor.

(v) There should be a supporting letter from either the cardiac transplant physician or the cardiac transplant surgeon at the cardiologist's institution who has been directly involved with the individual and can certify his or her competence.

(vi) That the individual has written a detailed letter to UNOS outlining his/her training and experience in UNOS approved heart transplant program(s) or its foreign equivalent.

(dd) If as of March 1, 1991 the physician serves as the designated cardiac transplant physician for a qualified UNOS cardiac transplant program and meets the cardiac transplant physician criteria in effect prior to that date, the physician's cardiac transplant program will continue to be UNOS-qualified in this respect so long as this same physician continues in his/her position with the program. If the physician ceases to serve the cardiac transplant program in question, that program must have on site a cardiac transplant physician who meets the requirements of (aa), (bb), (cc), (dd), (ee), (ff), or (gg) above and below in order to remain UNOS-qualified. If the physician ceases to serve the cardiac transplant program that he/she served as of March 1, 1991, and desires to become the designated cardiac transplant physician at another program, he/she must meet the requirements of (aa), (bb), (cc), (dd), (ee), (ff), or (gg) above and below.

(ee) The training/experience requirements for a heart transplant physician can be met during the individuals cardiology fellowship if the following conditions are met:

(i) That the individual will have completed a minimum of 3 years of pediatric cardiology fellowship training as mandated by the American Board of Pediatrics and accredited by the RRC-Ped. That 3-year program includes an aggregate of 6 months of clinical care for transplant patients.

(ii) That this training be in addition to other clinical requirements for general cardiology training.

(iii) That the individual will have been involved in the primary care of 20 or more pediatric heart or

heart/lung recipients from the time of their transplant. This training will have been under the direct supervision of a qualified cardiac transplant physician and in conjunction with a cardiac transplant surgeon at a UNOS approved cardiac transplant center that conducts 10 or more heart or heart/lung transplants each year. This application must be supported by a recipient log. Such a log should include at least the medical record and/or UNOS identification number and the date of transplant.

(iv) That the individual has been involved with and has a current working knowledge of cardiac transplantation including the care of acute and chronic heart failure, donor selection, use of mechanical assist devices, recipient selection, pre and post-operative hemodynamic care, post-operative immunosuppressive therapy, histologic interpretation and grading of myocardial biopsies for rejection, and long-term outpatient follow-up.

(v) The individual should participate as an observer in 3 organ procurements and subsequent transplants. In addition the individual should observe the selection and management of at least 3 multiple organ donors that include the heart and/or heart/lung. These cases must be documented. Documentation should include the date of procurement, medical record and/or UNOS identification number, and location of the donor.

(vi) That the individual has a letter sent directly to UNOS from the director of the individual fellowship training program, as well as the supervising qualified cardiac transplant physician, verifying the fellow has met the above requirements and that he or she has qualified to become a medical director of a cardiac transplant program.

(vii) That the individual has written a detailed letter to UNOS outlining his/her training and experience in a UNOS approved heart transplant program(s) or its foreign equivalent.

(ff) If the physician is not a cardiologist, he/she can function as a heart transplant physician if the following conditions are met:

(i) That items (aa)i-iii and (aa)v are met.

(ii) That the individual is board certified or eligible in Internal Medicine and in the subspecialty of his/her major area of interest and qualified through specific training or experience to be a transplant physician for other solid organ transplantation.

(iii) Adequate association with cardiology service must be documented by letters of support.

(gg) In the case of a change in the primary transplant physician at a UNOS approved transplant program, if items (aa) i or (cc) i-ii are not met, the replacement physician, whether a cardiologist or not, can function as a heart transplant physician for a maximum period of 12 months if the following conditions are met:

(i) That the remaining parts of (aa) or (cc), as applicable, are met.

(ii) That if the individual is qualifying as primary transplant physician by virtue of training, the individual will have been involved in the primary care of 10 or more heart or heart/lung transplant recipients from the time of their transplant. This training will have been under the direct supervision of a qualified cardiac transplant physician and in conjunction with a cardiac transplant surgeon at a UNOS approved cardiac transplant center that conducts 20 or more heart or heart/lung transplants each year. The application must be supported by a recipient log. Such a log should include at least the medical record and/or UNOS identification number of the recipient and date of transplant.

(iii) That if the individual is qualifying as primary transplant physician by virtue of acquired clinical experience, this experience is equal to 12 months on an active heart transplant service as the heart transplant physician or under the direct supervision of a qualified heart transplant physician and in conjunction with a heart transplant surgeon at a UNOS approved heart transplant center. Additionally, the individual will have been involved in the primary care of 10 or more heart or heart/lung transplant recipients from the time of their transplant. This experience will have been as the cardiac transplant physician or under the direct supervision of a qualified cardiac transplant physician or in conjunction with a cardiac transplant surgeon. The individual must have followed these patients for a minimum of 3 months post transplant. The application must be supported by a recipient log. Such a log should include at least the medical record and/or UNOS identification number of the recipient and date of transplant

(iv) That a consulting relationship with counterparts at another UNOS member transplant center approved for transplantation of the same organ has been established and documented.

(v) That activity reports are submitted to UNOS at 2-month intervals describing the transplant activity and results, physician recruitment efforts, and such other operating conditions as may be required by the Membership and Professional Standards Committee to demonstrate to the satisfaction of the Committee ongoing quality and efficient patient care. The reports must show that the individual is making suf-

ficient progress to meet the objective of involvement in the primary care of at least 20 transplant recipients or that the program is making sufficient progress in recruiting and bringing to the program a transplant physician who meets this criterion as well as all other UNOS criteria for a qualified heart transplant physician by the date that is 12 months from the date of approval of the program under this section.

This is a revision of the January 1995 document that was written by Sharon A. Hunt, MD, FACC – Chair; Michael R. Bristow, MD, FACC; Spencer H. Kubo, MD, FACC; John B. O'Connell, MD, FACC; and James B. Young, MD, FACC.

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

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Patients with congenital heart disease have traditionally been managed by pediatric cardiologists and cardiovascular surgeons. Significant advances in surgical and medical management have allowed increasing numbers of patients with congenital heart disease to survive into adulthood. These patients often present complex combinations of problems that may be unfamiliar to those who undergo a traditional medical (internal medicine) cardiology training program (1,2). Medical cardiologists are experts in the care of patients with acquired diseases of the heart and circulation, but currently most have little training in congenital heart disease, particularly in complex disorders. This report suggests an initial approach to the more systematic training of medical cardiologists in the recognition and care of adults with congenital heart disease.

Levels of Training

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

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. 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 the sequelae of medical management, invasive transcatheter therapy, and surgical correction or repair. Specific disease categories of commonly treated disorders should be emphasized (see Postoperative residua and sequelae row of Table 1). However, for trainees with Level 1 expertise, consultation with a pediatric cardiologist or Level 2- or Level 3-trained clinician will be advisable when major management decisions are made about patients.

Level 2 represents additional training for fellows who plan to care for adult patients with congenital heart disease so that they may acquire expertise in the evaluation and management of such patients. Level 2 training requires 1 year of training in adult congenital heart disease.

Level 3 training represents the level of knowledge needed by those graduates who wish to make a commitment to this field and become competent in the care of the entire spectrum of adult patients with congenital heart disease. Level 3 trainees require 2 years of training. Such training would be sufficient to pursue an academic career, to train others in the field, or to direct an adult congenital heart disease clinic.

Level 1: Basic Training for all Medical Cardiology Fellows

All medical cardiology trainees should be exposed to a core of information regarding adults with congenital heart disease. 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 congenital heart disease and for periodic discussions of ongoing care.

We suggest that at least 6 hours of formal lectures within the core curriculum of the training program be devoted to congenital heart disease in adults. Table 1 indicates the content suggested for these 6 hours, covering key basic and clinical aspects of these disorders.

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

Core Curriculum	Knowledge Areas
Basic science	Anatomy, pathology, physiology, and genetic counseling
Natural history	Clinical recognition and care of patients with common defects presenting in adulthood
Postoperative residua and sequelae	Includes but is not limited to specific diagnoses such as tetralogy of Fallot, atrial and ventricular septal defects, transposition of the great arteries (atrial baffle and arterial switch operations), single ventricle (Fontan operation), and left ventricular outflow tract obstructions (all levels of aortic and pulmonic stenosis and coarctation of the aorta)
Other	Indications for and access to local regional expert consultation

In addition to the didactic material in the core curriculum, trainees ideally should be exposed to adult patients with congenital heart disease on a regular basis. This could be done in the context of ongoing weekly case conferences 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 congenital heart disease. In addition, trainees are encouraged to become involved in an ongoing congenital heart disease clinic or to see older children or adolescents with a pediatric cardiology colleague, or both.

During rotations in electrocardiography, electrophysiology, echocardiography (both transthoracic and transesophageal), nuclear cardiology, and the cardiac catheterization laboratory (including invasive transcatheter techniques), and when being trained in other imaging techniques (e.g., magnetic resonance imaging and computed tomography), trainees should be exposed to the evaluation of congenital heart disease with these diagnostic modalities. Didactic material for these rotations should include management of the adult with congenital heart disease.

Level 2: Special Expertise in Adults With Congenital Heart Disease

At least 1 year of concentrated exposure is necessary for those trainees who wish to care independently for adult patients with congenital heart disease. Table 2 indicates the knowledge areas that should be covered during this year.

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

1. Participation in a regular (at least weekly) clinic organized for the care of adults with congenital heart disease. 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, including exposure to neonates and children with congenital heart disease
3. Acquisition of familiarity with the range of diagnostic and therapeutic methods, including direct experience in echocardiography and cardiac catheterization and acquisition of understanding of the applications of transcatheter techniques both for arrhythmia ablation and for hemodynamic intervention
4. Participation in the perioperative care of patients with congenital heart disease (preferably in adults), including direct observation of surgical repair
5. Engagement in the perioperative care of in-hospital patients with congenital heart disease with both cardiac and noncardiac problems

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 congenital heart disease (preferably, this faculty member would have received Level 3 training).

Level 3: Advanced Expertise in Adults With Congenital Heart Disease

To obtain a comprehensive understanding of all aspects of congenital heart disease, a 2-year program is required with continued participation in clinical practice relating to con-

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

Anatomy, physiology, clinical presentation, and natural history of specific lesions
Diagnostic methods
Electrocardiography
Significance of arrhythmias/electrophysiologic testing
Chest roentgenogram
Echocardiography, both transthoracic and transesophageal
Catheterization/angiography
Radionuclide angiography
Other imaging methods; specifically MRI/CT
Therapeutic methods
Pharmacologic management
Surgical procedures
Catheter interventional procedures
Residua and sequelae of interventions (surgical and catheter)
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 indicates computed tomography; MRI, magnetic resonance imaging.

genital heart disease. In addition to the above 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 congenital heart disease, with trainees demonstrating a comprehensive understanding of the entire hemodynamic spectrum of anatomic abnormalities in congenital heart disease. 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 congenital heart disease.

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

The specific numbers of patients and procedures that will be required to develop expertise in this discipline have not been well defined. The several currently active multidisciplinary programs that train clinicians in this area typically have well-delineated populations of at least 500 adult patients and have regularly scheduled clinics that encompass 10 to 20 patients per week, including diagnostic procedures.

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Task Force 10: Training in Preventive Cardiovascular Medicine

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For over 50 years, the mission of the American College of Cardiology and the American Heart Association has been to ensure optimal care for persons with cardiovascular disease or the potential for developing it. Through education and other efforts, the cardiovascular specialist is expected to contribute significantly to both the treatment and prevention of cardiovascular disease.

The decade of the 1990s witnessed explosive increases in knowledge concerning the specific roles of various risk factors in atherosclerosis, hypertension, thrombosis, and other forms of vascular dysfunction. At the same time, clinical trials proved conclusively that strategies aimed at the appropriate detection and modification of various risk factors can slow progression of atherosclerosis and hypertension and reduce the occurrence of clinical events in both primary and secondary prevention settings. Clinical outcomes can be improved by promotion of favorable life habits and behaviors and by proper use of drug treatment in selected patients. Preventive interventions are clearly efficacious, but their application in clinical practice is not optimal in almost any practice setting. Prevention of cardiovascular disease, indeed prevention of the risk factors themselves, is no longer peripheral to the practice of a cardiovascular specialist, as it once was thought to be. Demographic trends predict that prevention and management of risk factors will be an ever-increasing requirement in the future practice of the cardiovascular specialist . Therefore, cardiovascular training programs must provide the necessary education and training to promote best practices among their trainees who bear the responsibility to provide optimal preventive services to their future 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

The faculty of the institution must be adequate in number and experience to conduct a training program in preventive cardiovascular medicine. It is highly desirable for certain members of the faculty to have special expertise in vascular biology, atherosclerosis, hypertension, disorders of lipid metabolism, diabetes, thrombosis, clinical epidemiology, cardiac rehabilitation, and the clinical pharmacology of cardiovascular drugs. It is likewise highly recommended that specific faculty in the cardiovascular medicine training program function as topic-area experts in one or more of the areas specified. Such faculty can serve as tangible role models for the practice of preventive cardiovascular medicine, in a manner analogous to that of the expert in echocardiography or invasive cardiology, for example. Role models are important for cardiovascular medicine fellows in their formative years, and prevention-oriented role models can function in this way.

Content of the Training Program

Optimal knowledge and skills required for the practice of cardiovascular disease prevention are extensive. Three levels of capability are defined.

Level 1

Level 1 training should be part of the knowledge base of all cardiovascular specialists and includes exposure to the general and specific areas discussed below.

General Content Areas

1. Genetics of cardiovascular disease and the interplay of genetics, environmental issues, and cardiovascular risk prediction
2. Clinical epidemiology and biostatistics. Certain areas might deserve special attention, including understanding of what a meta-analysis is, understanding and use of software for tracking of experimental data, and use of statistical analysis programs.
3. Principles of clinical trials
4. Principles of outcomes research. Programs should also offer teaching that relates to medical economics and cost/benefit analysis.
5. Principles of clinical pharmacology
6. Principles of behavior change and aspects of compliance
7. Principles of disease management and multidisciplinary system development

Specific Content Areas

Exposures to the following specific content areas are essential:

1. Prevention, diagnosis, and treatment of primary and secondary hypertension. In-depth familiarity with the guidelines in the sixth (or subsequent) report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (2) that deal with prevention and management of hypertension is essential for all cardiovascular specialists.

2. Prevention, diagnosis, and treatment of primary and secondary dyslipidemias. In-depth familiarity with National Cholesterol Education Program guidelines (3) and their application to prevention and management of lipid problems is essential for all cardiovascular specialists.
3. Prevention, diagnosis, and treatment of thrombosis and hypercoagulable states
4. Recognition and management of smoking cessation and nicotine addiction (4)
5. Cardiac rehabilitation and multidisciplinary approach (5)
6. Exercise physiology
7. Nutrition and its effects on the cardiovascular system
8. Psychosocial and behavioral aspects of cardiovascular diseases (6). Particular attention should be given to the role of affective disorders, especially depression and anxiety, in management of cardiovascular disease. The importance of adherence and compliance to therapies, especially the role of behavioral interventions, should also be stressed.
9. Understanding of the physiology and management of metabolic disorders that heighten cardiovascular risk, such as diabetes (7), obesity, and the "insulin resistance syndrome"
10. Understanding of gender (8) and racial differences in cardiovascular risk and prevention
11. Understanding of population demographics (1) as they apply to cardiovascular disease causation and prevention, with particular emphasis on aging and socioeconomic status

Training in these areas should ideally be undertaken in a 1-month (or longer) rotation in preventive cardiovascular medicine. An acceptable alternative would be a 1-month (or longer) rotation in a comprehensive cardiovascular rehabilitation program that incorporates a broad range of preventive approaches besides the traditional rehabilitation effort focused mostly on physical exercise (9). As an alternative, training in these areas could be integrated into consultative, inpatient, and outpatient rotations and didactic components of core cardiovascular medicine programs. If the latter approach is taken, the time 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 cardiology or risk factors, such as the American College of Cardiology Heart House Course in Preventive Cardiology.

Level 2

Level 2 training should achieve a level of expertise for the cardiovascular specialist so that the trainee could serve as an independent consultant to other cardiovascular practitioners in the prevention of cardiovascular disease and 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 and lipid clinics or services, coagulation laboratories, vascular laboratories, and clinical and cardiac rehabilitation services, as well as 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.

The clinical application of information contributed by newly emerging fields, such as vascular biology and medicine, lends itself to the development of the clinician/scientist and the expert teacher/clinician.

Level 3

Level 3 requires advanced training to qualify as a director of a clinical service or research program or both. Examples include the director of a preventive cardiology, 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.

Table 1. Summary of Training Requirements for Preventive Cardiovascular Medicine

Level	Duration of Training, mo	Cumulative Duration of Training, mo	Types of Training Experiences
1	1	1	Genetics of CVD, risk prediction, clinical epidemiology, biostatistics, clinical trials, outcomes research, clinical pharmacology, behavior change, 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 area

CVD indicates cardiovascular disease.

Training at this level would require at least 1 year of a 36-month program, and this level of expertise 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 cardiology services incorporate the skills and knowledge of multiple providers, including cardiovascular physicians, nurses, dietitians, behavioral medicine specialists, and exercise physiologists. They operate on principles of interdisciplinary and multidisciplinary teamwork, and they use systematic 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 that trainees (and faculty) have acquired appropriate knowledge of preventive cardiovascular medicine.

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

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Vascular diseases are encountered frequently by cardiovascular physicians. 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 (1-3). Yet, heretofore, training in vascular medicine during a cardiovascular fellowship has been inadequate to accommodate the clinical demands of this contemporary paradigm. Accordingly, three 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 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. At least the equivalent of 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. 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 also should be trained to perform a comprehensive preoperative evaluation of the patient undergoing vascular surgery, to be cognizant of the indications and risks of preoperative 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 spiral computed tomography, magnetic resonance imaging, and conventional angiography, and recognize the indications for catheter-based interventions and surgical revascularization.

All cardiovascular medicine fellowship candidates should have at least 4 months of training in the catheterization laboratory. They should participate in noncardiac 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 25 patients with whom they are involved from precatheterization clinical evaluation to final disposition. This training will not qualify the trainee to independently perform noncardiac angiography.

Structure of the Training Program

Faculty

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

*Representative of the Society for Vascular Medicine and Biology

medicine specialists. In most 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. The fellow who wishes to be trained in peripheral vascular intervention will require additional training as outlined below (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; at least one-half to 1 day per week throughout the year should be spent in the outpatient vascular medicine clinic. In addition, at least 3 months should be spent in the noninvasive vascular laboratory and 1 to 2 months in the peripheral vascular catheterization laboratory. 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 hospital service and outpatient clinic should include experience with risk factor modification, including treatment of dyslipidemia, hypertension, and hypercoagulable states, because these are important components of many vascular diseases. Additional rotations could be allocated to vascular surgery, hematology, neurology, rheumatology, and magnetic resonance imaging 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 and its branches; (3) the carotid arteries; (4) infrainguinal bypass grafts; and (5) 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 . These include but are not limited to 100 venous, 100 carotid artery, and 100 arterial duplex ultrasound studies, as well as 100 physiologic arterial examinations.

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 25 peripheral diagnostic angiograms and 25 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 interventionist (see Level 3).

Structure of the Training Program

Faculty

Ideally, the trainee should be exposed to individuals who have special training in vascular medicine and cardiovascular diseases. However, it is recognized 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 listed above. A peripheral vascular catheterization laboratory equipped as stated below 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.

Trainee Evaluation

As with every successful postgraduate training program, this program requires bidirectional evaluations. The faculty evaluates and provides positive and negative feedback to the trainee, and the trainee evaluates the faculty. 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. It is anticipated that the American Board of Medical Subspecialties will develop a certifying examination for extra qualifications in vascular medicine. The fellow will be expected to take and pass this examination.

Level 3: Training for Peripheral Vascular Catheterization and Intervention

Noncardiac angiography (arterial and venous) and catheter-based interventional procedures are essential components of a modern clinical cardiology practice (5-7). Therefore, all cardiologists should be knowledgeable in these areas.

The trainee performing noncardiac arteriography and venography requires additional training to obtain the basic fund of knowledge, technical skills, and the clinical judgment requisite for performing these invasive studies. The trainee who plans to perform noncardiac catheter-based therapeutic procedures will be required to complete additional time and training in these special procedures beyond training in basic peripheral vascular catheterization and angiography.

Components of Training

Trainees who plan to perform independent noncardiac or peripheral vascular catheterization (arteriography and venography) require additional training during their 3-year fellowship regarding vascular access, knowledge of the normal vascular anatomy and common variants, and knowledge of the common patterns of collateral formation. They must receive additional education regarding 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, and other X-ray equipment, as well as cine processing, digital imaging, and image archiving, is required. An understanding of the fundamental principles of pressure waveform recording and analysis is mandatory.

Trainees in noncardiac diagnostic angiography should receive specific training in the techniques of antegrade femoral artery access, contralateral femoral artery access, and vascular closure devices.

Trainees planning to perform peripheral vascular interventional procedures must have knowledge of the indications, limitations, and complications of these procedures, as well as an in-depth understanding of the alternative treatment methods. Such trainees must obtain specialized experience in therapeutic peripheral vascular intervention during a fourth year of interventional fellowship training devoted to interventional cardiology.

Level 3 training in peripheral angiography and catheter-based 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 half-day per week in an outpatient vascular medicine clinic, and 1 month in a noninvasive vascular laboratory 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. 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 Training Program

Faculty

To ensure quality control of training and diagnostic studies, the training program must have a director of the catheterization laboratory who has primary responsibility for administration and teaching in the laboratory. More than one faculty cardiologist is required to participate in the noncardiac invasive training of the fellows.

When training is limited to diagnostic peripheral angiography, the program director must be at least board certified in cardiovascular diseases or have equivalent credentials. For training in noncardiac vascular intervention, the program director must be board certified in interventional cardiology or have equivalent credentials.

All faculty responsible for training fellows in diagnostic peripheral angiography should be board certified or board eligible by the American Board of Internal Medicine Subspecialty Board on Cardiovascular Disease and recognized as experts in diagnostic noncardiac angiography or have equivalent credentials. For training in peripheral vascular interventional procedures, there must be at least one cardiologist on the faculty recognized by his or her peers as an expert in noncardiac catheter-related intervention.

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 (7). Peripheral vascular surgery must be performed in the training institution to support catheter catheter-based interventions.

Patients

All trainees should be exposed to adult patients with vascular diseases as outlined above. The trainee planning a career in the angiography laboratory must be trained to perform studies in acutely and chronically ill patients, including emergency patients with acute limb ischemia.

Duration of Training

For the trainee who plans to independently perform noncardiac diagnostic angiography, a minimum of 8 months of training in the catheterization laboratory is required, during which time the minimum number of cases required by the ACC peripheral angiography guidelines must be met (7). These procedures may be performed in conjunction with diagnostic cardiac catheterization procedures. These 8 months may be distributed throughout the 3-year cardiovascular medicine fellowship.

For trainees planning to perform peripheral vascular interventional procedures, an additional fourth year of dedicated interventional fellowship training is required, during which time the minimum requirements specified by the most current ACC training guideline document must be met (7). This training can run concurrently with a coronary intervention training. Current guidelines for competence indicate that trainees should perform at least 100 diagnostic angiograms, 50 peripheral angioplasties, and 10 peripheral thrombolytic infusions.

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 desires special training in diagnostic noncardiac angiography 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 performance of at least the minimum number of procedures set forth in the ACC training program guidelines (7). Evaluation of the trainee during a fourth year of study for catheter-based 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 ACC training program guidelines (7).

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

Level	Duration of Training, mo	Cumulative Duration of Training, mo	Components of Training	Cumulative Number of Procedures*
1	2	2	Evaluation and management of arterial, venous, and lymphatic disease Evaluation and management of atherosclerotic risk factors and hypercoagulable states Noninvasive vascular laboratory Diagnostic peripheral angiography	
2 (*Vascular Medicine Specialist)*	12	14	Outpatient vascular medicine clinic, one-half to 1 day each week Inpatient vascular medicine consultation service, 2 to 3 months Noninvasive vascular laboratory, 3 months Peripheral vascular catheterization, 1 to 2 months Elective rotations, each 1 month: vascular surgery, hematology, rheumatology, and/or magnetic resonance	Noninvasive vascular laboratory 100 Venous ultrasounds 100 Carotid artery ultrasounds 100 Limb artery ultrasounds 100 Physiologic arterial examinations Peripheral vascular catheterization† 25 Diagnostic angiograms 25 Peripheral interventions
3 (*Peripheral Vascular Intervention)*	12	22††	Outpatient vascular medicine clinic, one-half day each week Inpatient medical consultation service, 1 month Noninvasive vascular laboratory, 1 month Peripheral vascular catheterization, 9 to 10 months	Peripheral vascular catheterization 100 Diagnostic noncardiac peripheral angiograms 50 Noncardiac peripheral angioplasties 10 Peripheral thrombolytic infusions/thrombectomy
3 (*Vascular Medicine Specialist plus Vascular Intervention)*		34‡‡	Outpatient vascular medicine clinic, one-half to 1 day each week Inpatient vascular medicine consultation service, 2 to 3 months Noninvasive vascular laboratory, 3 months Elective rotations, each 1 month: vascular surgery, hematology, rheumatology, and/or magnetic resonance Outpatient vascular medicine clinic, one-half day each week Inpatient medical consultation service, 1 month Noninvasive vascular laboratory, 1 month Peripheral vascular catheterization, 9 to 10 months	Noninvasive vascular laboratory 100 Venous ultrasounds 100 Carotid artery ultrasounds 100 Limb artery ultrasounds 100 Physiologic arterial examinations Peripheral vascular catheterization† 25 Diagnostic angiograms 25 Peripheral interventions Peripheral vascular catheterization 100 Diagnostic noncardiac peripheral angiograms 50 Noncardiac peripheral angioplasties 10 Peripheral thrombolytic infusions/thrombectomy

*These are estimates based on the most recently published guidelines and will be kept current as guidelines are updated.

†Also required for trainees planning to undertake Level 3 training

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). Trainees wishing to pursue Level 3 training should have completed an aggregate of 8 months of prior training in diagnostic catheterization as required for Level 3 training in coronary intervention. In addition, they should have completed the 2 months of Level 1 training, yielding a total of 22 months. Level 2 training for a vascular medicine specialist is not required for interventional year.

¶2 months of vascular medicine as defined by Level 1, plus 12 months of Level 2 training. Level 2 training is not a prerequisite for Level 3 training but is intended for individuals who want to become a vascular medicine specialist.

††Including 2 months of vascular medicine training as defined by Level 1, 8 months of diagnostic catheterization training, and 12 months of interventional lab training. Interventional training for Level 3 requires a 4th year. The 12 months of Level 2 training are not required for this interventional training year.

‡‡Including 2 months of Level 1 and 12 months of Level 2 vascular medicine training, 8 months of diagnostic catheterization training, and 12 months of interventional lab training.

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Task Force 12: Training in Cardiovascular Magnetic Resonance

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Magnetic resonance methods (Table 1), the newest of the cardiovascular imaging modalities, provide useful, sometimes unique information with which all cardiologists should be conversant. Training in magnetic resonance for cardiology fellows should be divided into three levels.

Training Levels

Level 1—General training (1 month) to provide the fellow with a working knowledge of cardiovascular magnetic resonance (CMR) methods.

Level 2—Specialized training (at least 3 months) designed to allow trainees to interpret CMR imaging studies.

Level 3—Advanced training (1 year) for those who ultimately want to pursue an academic career in CMR, including patient care, teaching, and research, and/or those who want to be responsible for the operation of a CMR facility.

Overview of CMR Training

The trainee 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 test results with other relevant clinical and laboratory data. A mentor in this context is an individual with the equivalent of Level 3 training. This training should be acquired through an Accreditation Council for Graduate Medical Education—approved cardiology or radiology program with expertise in CMR and under the aegis of a qualified mentor or in a laboratory accredited by the Intersocietal Commission on the Accreditation of Magnetic Resonance Laboratories. The trainee should maintain a logbook or other specific records to document cases reviewed and didactic hours in which the trainee has participated.

The depth of knowledge will increase with increasing levels of training. In the case of the advanced trainee, specialized training and research should be offered as a part of an established broad-based training program; the preceptor should have Level 3 (or the equivalent) training in CMR. CMR training consists of several components (Table 2).

Table 2. Components of CMR Training

1. Didactic activities
a. Organized lectures
b. Self-study
2. Interpretation of CMR case studies
3. Hands-on experience

CMR indicates cardiovascular magnetic resonance.

Level 1: General Training (1 Month Minimum)

The trainee should have intensive 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 activities. This experience should provide a basic background in CMR sufficient for the practice of adult cardiology but not for the practice of CMR. As a practical matter, many fellowship programs may not be able to fulfill CMR training. In these instances, fellows should be encouraged to obtain experience at an alternate program with an appropriate training program in CMR.

Didactic Activities

Interpretation of CMR Studies. During their 1-month rotation, trainees should actively participate in daily CMR study

Table 1. Classification of Cardiovascular Magnetic Resonance Procedures

1. Standard MRI procedures, including:
a. Tomographic still-frame MRI for morphology using “bright” and/or “dark blood” methods with and/or without contrast agent
b. Cine MRI for ventricular function and other dynamic imaging studies at rest and/or stress (exercise or pharmacologic)
c. Magnetic resonance angiography and cine MRI of the great vessels, peripheral vessels, anomalous coronary arteries, and coronary bypass grafts
2. Less common procedures, including:
a. Myocardial tagging (approach unique to CMR that allows detailed evaluation of myocardial function)
b. Phase-contrast velocity mapping for blood flow quantification
c. First-pass, contrast-enhanced MRI (for myocardial perfusion imaging at rest and/or during stress)
d. Delayed contrast-enhanced MRI (for myocardial tissue characterization)
e. Magnetic resonance angiography of proximal native coronary arteries.

CMR indicates cardiovascular magnetic resonance; MRI, magnetic resonance imaging.

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interpretation under the direction of a qualified physician-mentor in CMR. For all studies in which angiographic or hemodynamic data or both are available, such information should be correlated with CMR studies. Studies should include the range of procedures listed in Table 1. Interpretative experience (a minimum of 50 cases) may include studies from an established teaching file of previous CMR cases.

Lectures and Self-Study in CMR. This component should consist of lectures on the basic aspects of CMR and parallel reading material. The lectures and reading should provide the fellow with an understanding of the applications of CMR. Specificity, sensitivity, diagnostic accuracy, utility in assessing prognosis and interventions, costs, indications, and pitfalls must be emphasized for each patient subset. Such information could be effectively transmitted within a weekly noninvasive or catheterization conference during which CMR imaging data are presented.

A basic understanding of nuclear magnetic resonance physics should be provided, including the following: (1) the physics of magnetic resonance as it relates to image contrast, including flow, T1, T2, and contrast agents; (2) sources of artifacts, including motion, arrhythmias, and metal objects; and (3) safety of devices and the magnet environment.

Hands-On Experience

Hands-on experience is not necessary for Level 1.

Level 2: Specialized Training (3 to 6 Months)

Training for Level 2 should begin with the CMR experience outlined in Level 1. Level 2 is for those trainees who wish to practice the specialty of CMR. Trainees must have at least 3 months of training, including the basic elements listed below. In training institutions with a high volume of CMR procedures, clinical experience may be acquired in as little as 3 months. In institutions with a lower volume of CMR procedures, a total of 6 months or more of clinical experience might be necessary to achieve Level 2 competence. The trainee would be expected to become familiar with the CMR techniques listed in Table 1.

Background

In addition to Level 1 training, understanding of CMR physics would need to be more advanced (see below).

Didactic Activities

Interpretation of CMR Studies. During their 3 to 6 months of experience, trainees should actively participate in daily CMR study interpretation under the direction of a qualified physician in CMR. For all studies in which other cardiac imaging data are available, such information should be correlated with the CMR studies. The trainee should interpret at least 100 CMR examinations during this training period, including 50 in which the trainee is a primary interpreter and operator of the scanner.

Lectures and Self-Study in CMR. Course work should include the components for Level 1 training but will include more advanced lectures and reading material. This work, with parallel reading activities, 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 and/or physicist on the basic physics of nuclear magnetic resonance in general and 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 echocardiography, spin echocardiography, echoplanar imaging, spirals, fast spin echocardiography, and three-dimensional echocardiography
   b. Specialized imaging sequences, including flow and motion, phase imaging, time of flight, contrast agents, and tagging
   c. Hardware components, including the elements of gradient coil design, receiver coils, and digital sampling
2. Applications and indications: Level 2 didactic activities should include discussion of the sensitivity, specificity, accuracy, utility, costs, and disadvantages of all of the techniques to be reviewed. The following techniques should be covered in the didactic program:
   a. Imaging of structure and tissue characterization (T1, T2, spin echocardiography, gradient echocardiography, and fat suppression)
   b. Imaging of function (cine and tagged cine magnetic resonance imaging)
   c. Volumetric imaging of mass, volumes, and ejection fraction (cine magnetic resonance imaging)
   d. Flow imaging (velocity encoded techniques)
   e. First-pass perfusion and delayed contrast-enhancement imaging (gadolinium-enhanced techniques)
   f. Magnetic resonance angiography (vascular and coronary)
   g. Basic magnetic resonance, clinically applicable spectroscopy methods, including pulse and acquire, DRESS (depth-resolved surface coil spectroscopy), ISIS (image selected in-vivo spectroscopy), and CSI (chemical shift imaging)
   h. CMR image analysis

Evaluation

The person responsible for the CMR training program must be responsible for assessing the competence of the trainee in CMR at the completion of the program. This is accomplished

by observing the trainee during the performance of studies and daily reading sessions and may be supplemented by formal testing.

Level 3: Advanced Training (12 Months Minimum)

For trainees who wish to pursue an academic career in CMR or to direct a CMR laboratory, an extended program is required. This can be part of a 4-year cardiology fellowship.

In addition to the recommendation for Level 2, the Level 3 program should include active participation in ongoing laboratory or clinical research or both, with individual responsibility for a specific portion of that research. Focused research projects with writing of one or more manuscripts is strongly encouraged.

In parallel with research activities, the trainee must participate in clinical imaging for the entire 12 months, which should include supervised interpretative experience in 200 cases. The trainee should have hands-on experience in 100 cases as the primary operator. Knowledge of nuclear magnetic resonance and imaging physics must be more advanced than Level 2 and include the following:

1. Analysis of why certain specialized imaging sequences are applicable for specific clinical protocols, including imaging of heart function, coronary arteries, perfusion, and angiography
2. Basic understanding of the clinically applicable spectroscopic methods
3. The rudiments of data collection, including capturing of digital data, the keeping of accurate databases and records, signal processing, and the importance of obtaining quantitative 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 Training Requirements for CMR

Level	Duration of Training, mo	Number of Examinations
1	1	50 Mentored interpretations
2	3 to 6	100 Mentored interpretations (50 as primary interpreter and operator)
3	12	200+ Mentored interpretations (100 as primary interpreter and operator)