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

Endorsed by the Heart Rhythm Society

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Clinical cardiac electrophysiology and cardiac pacing have merged into a common cardiac subspecialty discipline. Today, complex cardiac arrhythmias are managed by physicians with special expertise in cardiac electrophysiology, the use of implantable pacemakers and implantable cardioverter-defibrillators (ICDs), 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. In addition, antiarrhythmic agents with diverse mechanisms of action are often used therapeutically alone or in conjunction with cardiac implantable electrical devices.

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. In 2002, updated recommendations were published (4). The current task force is charged with updating these training guidelines based on changes in the pacing and cardiac electrophysiology field since that time.

GENERAL STANDARDS AND ENVIRONMENT

Facilities and Faculty

Three organizations—the American College of Cardiology (ACC), the American Heart Association (AHA), and the Heart Rhythm Society (HRS)—have addressed training requirements and guidelines for permanent pacemaker selection, implantation, and follow-up (5,6); guidelines for the implantation and follow-up of ICDs in cardiovascular practice (7,8); guidelines for training in catheter ablation procedures (9,10); and teaching objectives for fellowship programs in clinical electrophysiology (11,12). The training recommendations for these three organizations are congruent and address new technologies, faculty, and facility requirements, as well as practice. 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. Faculty responsible for training must be board certified in clinical cardiac electrophysiology or possess equivalent qualifications. In addition, there must be a minimum of two key clinical cardiac electrophysiology faculty members, including the program director. In programs with a total of more than two residents enrolled, a ratio of such faculty to residents of at least 1:1 must be maintained (13).

LEVELS OF TRAINING

Level 1

Within the cardiology core training program, Level 1 should comprise at least 2 months of 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 non-pharmacologic 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 non-invasive and invasive techniques related to the diagnosis and management of patients with cardiac arrhythmias that include ambulatory electrocardiographic (ECG) monitoring, event recorders, exercise testing

for arrhythmia assessment tilt-table testing invasive electrophysiologic studies, and implantation of cardiac arrhythmia control devices. 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 non-cardiac surgical patients, 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. Trainees should learn about the indications for the use of biventricular pacing in patients with congestive heart failure.

The cardiology trainee should be formally instructed in and gain experience with the insertion, management, and follow-up of temporary pacemakers (4); measurement of pacing and sensing thresholds and recording of 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. The cardiology trainee should be formally instructed in and gain experience with the application of and use of transcutaneous pacing systems. These experiences can be obtained throughout the 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 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 or actively involved in the interrogation and programming of cardiac implantable electrical devices on a heart failure service.

Level 2 trainees should meet all Level 1 training requirements and should obtain advanced training in normal and abnormal cardiac electrophysiology and mechanisms of arrhythmias. Level 2 training consists of a minimum of 6 months of training in non-invasive arrhythmia management techniques designed to develop advanced competence and proficiency in the diagnosis, treatment, and longitudinal care of patients with complex arrhythmias. Exposure and proficiency in the performance and interpretation of other non-invasive tests related to the evaluation of patients who have arrhythmias should be part of the training. Level 2 trainees should have a thorough knowledge of the basic and clinical pharmacology of antiarrhythmic agents and demonstrate proficiency in their use.

Of special importance for the Level 2 trainee is the acquisition of skills and experience for managing inpatients and outpatients with complex cardiac arrhythmias, including programming and follow-up management of all types of bradycardia pacing, biventricular pacing, and ICD systems. The trainee is expected to function as the primary programming operator who interrogates, interprets, prescribes, and reprograms devices in at least 100 patients. The trainee at this level must also acquire advanced expertise in temporary 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 by itself does not qualify the trainee to perform these invasive procedures. The Level 2 trainee has the option of obtaining additional training in the surgical aspects of pacemaker implantation or may choose the additional training required for invasive cardiac electrophysiology, or both, as described under Level 3.

Level 3

This level of training is designed for the individual who wishes to specialize in invasive diagnostic and therapeutic cardiac electrophysiology (clinical cardiac electrophysiology) (16). Requirements of Level 1 and Level 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. Given the complexity of the field and the growing amount of information and new procedures, it is common for trainees to extend training for an additional year or more to gain advanced expertise in specific procedures. 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 Level 2 requirements, trainees should perform at least 150 electrophysiologic procedures and "be a primary operator and analyze 100 to 150 initial diagnostic studies. At least 50 to 75 of these procedures should involve patients with supraventricular arrhythmias. Because therapy with antiarrhythmic devices forms a major part of current electrophysiology practice, the trainee should also have been a primary

Table 1. Cardiac Arrhythmia and Electrophysiology Curriculum Training Summary

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

ABIM = American Board of Internal Medicine; CCEP = Clinical Cardiac Electrophysiology.

operator during ≥25 electrophysiological evaluations of implantable antiarrhythmic devices" (17).

Electrophysiologic procedures should cover the total spectrum of arrhythmias, both supraventricular and ventricular tachyarrhythmias as well as bradyarrhythmias. 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 post-training mentored practice.

Expertise in catheter placement, programmed electrical stimulation, endocardial mapping, catheter ablation, and interpretation of data must be ensured by the electrophysiology program director. The endocardial mapping experience should include 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 (17). To gain expertise in atrial fibrillation ablation requires additional expertise in catheter manipulation and integration of knowledge related to three-dimensional mapping systems. Given the rapid evolution of new mapping technologies, it is unlikely that the trainee will be exposed to all mapping technologies as part of their training. Trainees should be exposed to tools for definition of intracardiac anatomy, such as intravascular ultrasound, cardiac magnetic resonance imaging, and computed tomographic scans. No numeric guidelines have been established for training in atrial fibrillation ablation, but it is anticipated that the Level 3 trainee should participate in 30 to 50 mentored atrial fibrillation ablations.

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). The trainee in electrophysiology also requires experience in left ventricular lead implantation procedures. Implantable cardioverter defibrillator implant exposure includes assisting with the device implantation, threshold and defibrillation threshold (DFT) testing at the time of implant and follow-up. This experience should include at least 15 device evaluations (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) unless they meet Level 3 training listed below in optional training for device implantation.

OPTIONAL TRAINING IN DEVICE IMPLANTATION (APPLICABLE TO LEVEL 2 OR LEVEL 3)

Level 2 and Level 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 right and left ventricular lead and ICD lead placement, threshold testing and programming of devices, principles of surgical asepsis, surgical techniques of implantation, and management of implant-related 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 one-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 pacemak-

ers, 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. The Level 3 trainee wishing to become proficient in implantation of biventricular pacing or defibrillating systems requires the above training and involvement in implantation and follow-up of 15 biventricular systems (6). He or she should be proficient at interpreting data gained from non-invasive tools such as echocardiography used in the evaluation of resynchronization therapies. Pacemaker lead extraction is a specialized procedure that requires special training but is not an obligate part of training for CCEP examination eligibility. Physicians being trained in lead extraction should perform a minimum of 20 lead extractions as the primary operator under the direct supervision of a qualified training physician (18).

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 post-operative 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 one year of dedicated clinical cardiac electrophysiology and device implantation training beyond the three-year cardiology program. In addition, Level 3 trainees must have an extensive knowledge of left ventricular lead indications, contraindications, and management of biventricular malfunctions and interactions, as well as postoperative complications. It has been advocated that physicians training in congestive heart failure/transplantation could pursue an additional year of training to achieve Level 2 and Level 3 competency in implantable devices by meeting all of the above COCATS training requirements (19,20). An alternate pathway for training in ICD implantation has been established for a small, finite group of physicians who have completed fellowship training and have been high-volume pacemaker implanters for three or more years (20). It is recommended that Level 3 fellowship training for ICD implantation follows the above COCATS requirements.

EVALUATION, COMPETENCE, AND PRIVILEGES

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

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

The ACGME has published the essential components of a specialized program for training in 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. The HRS also has a written examination of special competence in device therapy, but it does not provide certification (21). 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 2002 document that was written by Gerald V. Naccarelli, MD, FACC, Jamie B. Conti, MD, FACC, John P. DiMarco, MD, FACC, and Philip T. Sager, MD, FACC.

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APPENDIX 1. Author Relationships With Industry for the ACCF 2006 Update for Training in Adult Cardiovascular Medicine—Task Force 6: Training in Specialized Electrophysiology, Cardiac Pacing, and Arrhythmia Management

Name	Consultant	Research Grant	Scientific Advisory Board	Speakers' Bureau	Steering Committee	Stock Holder	Other
Dr. Jamie B. Conti	None	Medtronic, Inc. Guidant Corp. St. Jude	Medtronic, Inc. St. Jude	None	None	None	None
Dr. John P. DiMarco	Novartis Guidant Medtronic St. Jude Medical	Guidant Sanofi-Aventis	None	Medtronic St. Jude Medical	None	None	None

APPENDIX 1. Continued

Name	Consultant	Research Grant	Scientific Advisory Board	Speakers' Bureau	Steering Committee	Stock Holder	Other
Dr. Gerald V. Naccarelli	Guidant Medtronic Sanofi-Aventis Wyeth-Ayerst Boehringer-Ingelheim Pfizer Astra-Zeneca Glaxo-Smith-Kline	Guidant Medtronic Sanofi-Aventis Wyeth-Ayerst Boehringer-Ingelheim	None	None	None	None	None
Dr. Cynthia M. Tracy	None	Medtronic, Inc. Guidant Corp.	None	None	None	None	None

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

APPENDIX 2. External Peer Reviewer Relationships With Industry for the ACCF 2006 Update for Training in Adult Cardiovascular Medicine—Task Force 6: Training in Specialized Electrophysiology, Cardiac Pacing, and Arrhythmia Management*

Peer Reviewer Name†	Representation	Consultant	Research Grant	Scientific Advisory Board	Speakers' Bureau	Steering Committee	Stock Holder	Other
Dr. Loren D. Berenbom	Board of Governors Reviewer	Medtronic	None	None	None	None	None	Medtronic Guidant St. Jude Medical–Underwrite EP fellowship
Dr. Peng-Sheng Chen	Organizational Reviewer–Heart Rhythm Society	None	None	None	None	None	None	Medtronic Guidant St. Jude–Donation of ICD and pacemaker for research in animal laboratories
Dr. Leonard S. Dreifus	Content Reviewer–ACCF Electrophysiology Committee	None	None	None	None	None	None	None
Dr. Bengt Herweg	Organizational Reviewer–Heart Rhythm Society	None	None	None	None	None	None	None
Dr. Alan Kadish	Content Reviewer–Individual Review	St. Jude Medical Lifewatch	St. Jude Medical Medtronic Guidant	None	None	None	None	None
Dr. Bradley P. Knight	Content Reviewer–ACCF Electrophysiology Committee	Guidant Medtronic CardioOptics	Guidant Medtronic CardioOptics	CardioOptics	Guidant Medtronic	None	None	None
Dr. Peter Kowey	Content Reviewer–ACCF Electrophysiology Committee	None	None	None	None	None	None	None

Continued on next page

APPENDIX 2. Continued

Peer Reviewer Name†	Representation	Consultant	Research Grant	Scientific Advisory Board	Speakers' Bureau	Steering Committee	Stock Holder	Other
Dr. Bruce D. Lindsay	Content Reviewer–Individual Review	None	None	None	None	None	None	None
Dr. Michael Mirro	ACC Official Reviewer–Board of Trustees	Cambridge Heart Life Cor Medical Informatics Engineering	Astra-Zeneca Metronic	None	Astra-Zeneca Medtronic Novartis Pfizer	None	Cambridge Heart Life Cor Medtronic Medical Informatics Engineering Pfizer	None
Dr. Andrea Russo	Content Reviewer–ACCF Electrophysiology Committee	None	Guidant Medtronic St. Jude Medical	None	Guidant Medtronic St. Jude Medical	None	None	None

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