TRAINING STATEMENT

2015 ACC/AHA/HRS Advanced Training Statement on Clinical Cardiac Electrophysiology (A Revision of the ACC/AHA 2006 Update of the Clinical Competence Statement on Invasive Electrophysiology Studies, Catheter Ablation, and Cardioversion)

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PREAMBLE

Since the 1995 publication of its Core Cardiovascular Training Statement (COCATS), the American College of Cardiology (ACC) has played a central role in defining the knowledge, experiences, skills, and behaviors expected of all clinical cardiologists upon completion of training. Subsequent updates have incorporated major advances and revisions—both in content and structure—including, most recently, a further move toward competency (outcomes)-based training, and the use of the 6-domain competency structure promulgated by the Accreditation Council for Graduate Medical Education (ACGME) and the American Board of Medical Specialties, and endorsed by the American Board of Internal Medicine (ABIM). A similar structure has been used by ACC to describe the aligned general cardiovascular lifelong learning competencies that all practicing cardiologists are expected to maintain. Many hospital systems also now use the 6-domain structure as part of medical staff privileging and peer-review professional competence assessments.

Whereas COCATS has focused on general clinical cardiology, ACC Advanced Training Statements define selected competencies that go beyond those expected of all cardiologists and require training beyond a standard 3-year cardiovascular disease fellowship. This includes sub-subspecialties for which there is an ABIM added-qualification designation, such as clinical cardiac electrophysiology (CCEP). The Advanced Training Statements also describe key experiences and outcomes necessary to maintain or expand competencies during practice.

The ACC Competency Management Committee oversees the development and periodic revision of the cardiovascular training and competency statements. A key feature of competency-based training and performance is an outcome-based evaluation system. Although specific areas of training may require a minimum number of procedures or duration of training time to ensure adequate exposure to the range of clinical disorders and to effectively evaluate the trainee, it is the objective assessment of proficiency and outcomes that demonstrates the trainee's achievement of competency. Such evaluation tools may include in-training examinations, direct observation, procedure logbooks, simulation, conference presentations, and multisource (360°) evaluations, among others. For practicing physicians, these tools may also include professional society registry or hospital quality data, peer-review processes, and patient satisfaction surveys. A second feature of a competency-based training program is the recognition that learners develop some competency components at different rates. For multiyear training programs, assessment of selected representative curricular milestones during training can identify learners or areas that require additional focused attention.

The recommendations in the ACC cardiovascular training statements are based on available evidence, and where evidence is lacking, reflect expert opinion. The writing committees are broad-based, and typically include content experts, general cardiology and sub-subspecialty training directors, practicing cardiologists, and early-career representatives. All documents go through a rigorous peer-review process. Recommendations are intended to guide the assessment of competence of cardiovascular care providers beginning independent practice as well as those undergoing periodic review to help ensure that competence is maintained.

This Advanced Training Statement addresses the added competencies required of sub-subspecialists in CCEP for diagnosis and management of patients with cardiac arrhythmias and conduction disturbances at a high level of skill. It is intended to complement the basic training in cardiac electrophysiology (EP) required of all trainees during the standard 3-year cardiovascular fellowship. The training requirements and designated clinical competencies in this report focus on the core competencies reasonably expected of all clinical cardiac electrophysiologists. It also identifies some aspects of CCEP that go beyond the core expectations and may be achieved by some clinical cardiac electrophysiologists, based on career focus, either during formal CCEP fellowship training or subsequently.

The work of the writing committee was supported exclusively by the ACC without commercial support. Writing committee members volunteered their time to this effort. Conference calls of the writing committee were confidential and attended only by committee members. To avoid actual, potential, or perceived conflict of interest arising as a result of relationships with industry or other entities (RWI) of writing committee members or peer reviewers of the document, each individual is required to disclose all current healthcare-related relationships, including those existing 12 months before initiation of the writing effort. The ACC Competency Management Committee reviewed these disclosures to identify products (marketed or under development) pertinent to the document topic. On the basis of this information, the writing committee was constituted to ensure that the Chair and a majority of members have no relevant RWI. Authors with relevant RWI were not permitted to draft initial text or vote on recommendations or curricular requirements to which their RWI might apply. RWI was reviewed at the start of all meetings and conference calls and updated as changes occurred. The RWI of authors and peer reviewers relevant to this document are disclosed in Appendixes 1 and 2, respectively. To ensure transparency, comprehensive healthcare-related disclosure information, including RWI not pertinent to this document, is posted online. Disclosure information for the ACC Competency Management Committee is also available online, as is the ACC disclosure policy for document development.

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1. Introduction

1.1. Document Development Process

1.1.1. Writing Committee Organization

The writing committee consisted of a broad range of members representing ACC, the American Heart Association (AHA), and the Heart Rhythm Society (HRS), identified because they perform ≥1 of the following roles: cardiovascular training program directors; EP training program directors; early-career experts; general cardiologists; EP specialists representing both the academic and community-based practice settings as well as small, medium, and large institutions; specialists in all aspects of CCEP, including catheter ablation, device management, antiarrhythmic drug therapy, lead extraction, and left atrial appendage occlusion/ligation; physicians experienced in training and working with the ACGME/Residency Review Committee as well as the ABIM examination writing committee; physicians experienced in defining and applying training standards according to the 6 general competency domains promulgated by the ACGME and the American Board of Medical Specialties and endorsed by the ABIM; and nurses. This writing committee met the College's disclosure requirements for relationships with industry as described in the Preamble.

1.1.2. Document Development and Approval

The writing committee convened by conference call and e-mail to finalize the document outline, develop the initial draft, revise the draft based on committee feedback, and ultimately approve the document for external peer review. In addition, the committee conducted a survey of EP training

program directors to obtain additional insight into procedural numbers to consider in writing committee deliberations.

The document was reviewed by 9 official representatives from the ACC, AHA, and HRS, as well as by 26 additional content reviewers, including CCEP training program directors, resulting in 417 peer review comments. The list of peer reviewers, affiliations for the review process, and corresponding RWI is included in Appendix 2. Comments were reviewed and addressed by the writing committee. A member of the ACC Competency Management Committee served as lead reviewer to ensure a fair and balanced peer review resolution process. Both the writing committee and the ACC Competency Management Committee approved the final document to be sent for organizational approval. The governing bodies of the ACC, AHA, and HRS approved the document for publication. This document is considered current until the ACC Competency Management Committee revises or withdraws it from publication.

1.2. Background and Scope

The original 1995 ACC recommendations for training in adult cardiology evolved from a Core Cardiology Training Symposium (1). After several iterations, COCATS 4 (2) focuses on trainee outcomes that require delineation of specific components of competency within the subspecialty, definition of the tools necessary to assess training, and establishment of milestones documenting the trainee's progression toward independent competency. Ultimately, the goal is for the trainee to develop the professional skill set to be able to evaluate, diagnose, and treat patients with acute and chronic cardiovascular disturbances.

The COCATS 4 document includes individual task force reports that address subspecialty areas in cardiology, each of which is an important component in training a fellow in cardiovascular disease. Task Force 11 of that document addresses training in arrhythmia diagnosis and management, cardiac pacing, and EP (3) and updated previous standards for general cardiovascular training for fellows enrolled in cardiovascular fellowship programs. It addresses faculty, facilities, equipment, and ancillary support. It also addresses training components, including didactic, clinical, and hands-on experience, and the number of procedures and duration of training. Importantly, the COCATS 4 Task Force 11 report did not provide specific guidelines for advanced CCEP training.

This document focuses on training requirements for advanced training in adult CCEP. For training standards related to pediatric EP, readers should refer to the SPCTPD/ACC/AAP/AHA Training Guidelines for Pediatric Cardiology Fellowship Programs Task Force 4: Pediatric Cardiology Fellowship Training in Electrophysiology (4) and to Recommendations for Advanced Fellowship Training in Clinical Pediatric and Congenital Electrophysiology: a Report From the Training and Credentialing Committee of the Pediatric and Congenital Electrophysiology Society (5).

1.2.1. Evolution of CCEP

Training in CCEP has become more complex as the clinical specialty has matured. The use of cardioactive drugs, implantation and use of cardiac implantable electronic devices (CIEDs) and left atrial appendage occlusion devices, and performance of invasive catheter ablation procedures for arrhythmia management have reached a level of sophistication that necessitates a re-evaluation of the training curriculum.

The ABIM requires 3 years of cardiology fellowship training before fellows may sit for the certification examination in cardiovascular medicine. Previously, it had required an additional year of training in CCEP for eligibility to take the certification examination in EP. It is now clear that CCEP demands a skill level to diagnose and treat patients with cardiac arrhythmias and conduction disorders that can no longer be attained in a single year of training. Two years of advanced training are now required to achieve the experience necessary to become a competent, independent expert in CCEP.

1.2.2. Levels of Training

COCATS 4 Task Force 11 was charged with updating previously published standards for training fellows in cardiovascular medicine and establishing consistent training criteria across all aspects of cardiology including advanced training in CCEP (3). For the cardiovascular fellowship, the following 3 levels of training have been delineated for training in arrhythmia diagnosis and management, cardiac pacing, and EP:

- **Level I training**, the basic training required of trainees to become competent consultant cardiologists, is required of all fellows in cardiology, and can be accomplished as part of a standard 3-year training program in general cardiology.
- **Level II training**, refers to additional training in ≥ 1 area that enables some cardiologists to perform or interpret specific procedures or render more specialized care for patients with certain conditions. Level II training in selected areas may be achieved by some trainees during the standard 3-year cardiovascular fellowship, depending on their career goals and use of elective rotations. Level II EP training during the general fellowship can provide the knowledge and skills needed for the fellow to provide specialized arrhythmia and CIED management, including implantation, interrogation and programming of pacemakers and implantable loop recorders (ILRs), and interrogation and programming of other CIEDs.
- **Level III training**, the primary focus of this document, requires additional training and experience beyond the cardiovascular fellowship for the acquisition of specialized knowledge and experience in performing, interpreting, and training others to perform specific procedures or render advanced, specialized care for specific procedures at a high level of skill. Level III training is required of individuals seeking subspecialty board certification in CCEP. Trainees in CCEP are

expected to have completed Level I training in all areas of general cardiovascular medicine before beginning their CCEP fellowship.

1.2.3. Methods for Determining Procedural Numbers

As noted in the COCATS 4 Task Force 11 report (3), the recommended number of procedures performed and interpreted by trainees under faculty supervision has been developed on the basis of published studies and guidelines, competency statements, and the experience and opinions of the members of the writing group. In addition, the writing committee surveyed CCEP training program directors to gain additional insight into procedural volumes. Of 100 directors of ABIM–recognized training programs, 33 responded. The procedural volumes suggested in this document were determined to be the minimum numbers sufficient to provide trainees with exposure to a variety and spectrum of complexity of clinical case material and to give supervising faculty sufficient opportunity to evaluate the competency developed by each trainee. The numbers of procedures that should be performed and/or interpreted successfully to achieve competence (see Section 4.2) are intended as general guidance, based on the educational needs and progress of typical CCEP trainees in typical programs. Those considering these volume figures should bear in mind the fundamental nature of educational milestones—that proficiency and outcomes, rather than length of exposure or the exact number of procedures performed, are the dominant requirements. Flexibility is inherent to this concept, and the ACGME mandates that all programs establish milestones for the acquisition of various competencies by trainees during the course of fellowship training.

2. General Standards

2.1. Faculty

Engaged faculty who are committed to teaching EP are the most important resource for a successful CCEP training program. Faculty must include specialists who are knowledgeable about basic and clinical aspects of EP, including anatomy, physiology, and pathophysiology of arrhythmias; both noninvasive and invasive diagnostic strategies and tests; and therapeutic options, including device-based therapies, medical management, and catheter ablation. The most recent ACGME Program Requirements for Graduate Medical Education in CCEP require a single designated program director and at least 1 additional key clinical faculty member (6). Each of the key clinical faculty members should be currently certified in CCEP by the ABIM. Furthermore, it is recommended that the number of ABIM-certified EP faculty equal or exceed the number of trainees enrolled in the training program. In addition to subject knowledge, faculty should be active both clinically and academically in the field of EP; should have experience and/or undergo professional training in teaching and mentoring; and must have sufficient time to fulfill the teaching, mentoring, and administrative responsibilities required for participation as active faculty in the CCEP training program.

2.2. Facilities

Facilities must include dedicated areas for both outpatient care and hospital-based treatment. An outpatient area that allows for longitudinal management of patients with arrhythmia problems is essential for complete training. In the hospital environment, a dedicated area that provides a safe and sterile environment for performing invasive electrophysiological procedures is necessary. The "Heart Rhythm Society Expert Consensus Statement on Electrophysiology Laboratory Standards: Process, Protocols, Equipment, Personnel, and Safety" provides general recommendations for the EP laboratory (7). In addition to physical space and facilities, the teaching environment must include a systems-based practice that allows for effective communication between the outpatient and inpatient environments and among different specialists. Facilities must also have systems or mechanisms in place that continuously evaluate quality and clinical outcomes.

2.3. Equipment

EP laboratories that provide a safe environment for invasive EP studies require imaging capabilities such as fluoroscopy and equipment for recording electrical and hemodynamic signals. In addition, specialized equipment, including alternative imaging methods (e.g., intracardiac echocardiography), advanced 3-dimensional mapping systems, ablation energy sources, CIED programmers, and extraction tools, is often necessary for safe and maximally-effective care of patients within the EP laboratory. Appropriate resuscitation equipment must be immediately available. In addition to facilities recommendations, the HRS Expert Consensus Statement on Electrophysiology Laboratory Standards: Process, Protocols, Equipment, Personnel, and Safety provides detailed recommendations on equipment necessary for performing invasive EP studies and placing CIEDs (7). Equipment and technology in the EP laboratory will continue to evolve rapidly, and a mechanism must be present that allows assessment and integration of important new technologies. In addition to equipment physically located within the EP suite, access to equipment and technologies outside of the EP suite, such as transesophageal echocardiography and advanced imaging (e.g., computed tomography [CT] scanning, cardiovascular magnetic resonance [CMR]), is essential for successful training in EP.

2.4. Ancillary Support

Adequate EP training requires interaction among many different specialties within the healthcare environment. Communication with, and access to, cardiologists who have advanced training in interventional cardiology, echocardiography and advanced imaging, and heart failure are critical. In addition, interaction with and availability of anesthesiologists and cardiothoracic surgeons are important for safe performance of some advanced EP procedures. Physicians from other fields of medical and surgical practice should be available for consultation, and access to other healthcare professionals, including genetic counselors, pharmacists, dieticians, occupational therapists, physical therapists, social workers, and biomedical engineers, is required.

3. Training Components

3.1. Didactic Program

Didactic instruction may take place in a variety of formats, including lectures, conferences, journal club, grand rounds, clinical case presentations, electrocardiogram (ECG) and electrogram review conferences, and patient safety or quality improvement conferences. Topics for discussion include genetics; anatomy; neural innervation; pathology; molecular, cellular, whole-animal and human EP; radiation safety; imaging; specific arrhythmia mechanisms; and patient-centered care. Didactic sessions and case reviews are important mechanisms for training in the interpretation of complex surface and intracardiac electrograms and in the evaluation and management of hospitalized patients and outpatients with cardiac arrhythmias. The latter includes the interpretation of ambulatory monitoring and CIED data critical for patient management. Hands-on use of simulators is an emerging platform to assist in the training of electrophysiologists, particularly in areas such as lead extraction, lead placement, trans-septal puncture, catheter ablation procedures, and preparation for infrequent emergencies such as cardiac perforation and tamponade (8,9). The same requirements for frequency of didactic instruction in general cardiology training are recommended for Level III training in CCEP (3). Moreover, it is expected that the CCEP trainees embark on a lifelong journey of education and learning that does not end with the completion of the fellowship, especially as new technologies and procedures are developed.

3.2. Clinical Experience

Level III trainees are required to have completed Level I training. Level II training can be completed before or in conjunction with Level III training. In either situation, Level III training cannot start until 3 years of cardiovascular training have been completed. Level III training requires robust clinical experiences in the outpatient and inpatient consultation settings and in the EP laboratory. In each of these clinical arenas, trainees assist in patient care in a supervised setting that provides for patient-centered education in all aspects of arrhythmia management. During a portion of clinical training, the Level III trainee is expected to act as a first-line consultant in arrhythmia management with appropriate on-site attending backup. In this capacity, the Level III trainee is expected to gather accurate, essential information from all sources, including medical interviews, physical examination, records, device interrogation, and diagnostic/therapeutic procedures; make informed recommendations about preventive, diagnostic, and therapeutic options and interventions that on the basis of clinical judgment, scientific evidence, and patient preferences; develop, negotiate, and implement patient management plans; and perform competently the diagnostic and therapeutic procedures considered essential to the practice of CCEP.

3.3. Hands-On Procedural Experience

Hands-on experience is essential for training in arrhythmia and CIED management. Level III training in CCEP requires a robust experience in the EP laboratory performing diagnostic and therapeutic EP procedures and device implantation and programming (permanent pacemakers, implantable cardioverter-defibrillators [ICDs], and cardiac resynchronization therapy [CRT] devices). The number of procedures that need to be completed during the 24 months of CCEP training is summarized in Section 4.2.

Level III trainees require experience in performing diagnostic EP studies and standard ablation procedures including ablation of atrioventricular (AV) nodal re-entrant tachycardia, atrial flutter, atrial tachycardia, accessory pathways (APs), the AV node, and ventricular arrhythmias (VAs). They also require experience in endocardial mapping including exposure to left heart mapping by the retrograde aortic and trans-septal approaches. Performance of procedures such as atrial fibrillation (AF) ablation, ablation of left-sided APs, and placement of left atrial appendage occlusion devices/ligation requires training in trans-septal catheterization. Ablation of AF, atrial tachycardia, premature ventricular complexes, and ventricular tachycardia (VT) requires additional expertise in catheter manipulation, delivery of ablative energy, and integration of knowledge related to 3-dimensional mapping systems and supporting modalities, such as intracardiac echocardiograms, CMR, and CT scans.

To gain skills in CIED implantation, the trainees should have adequate supervised experience performing this procedure (see Section 4.2). CIED lead extraction is a specialized procedure that requires special training but is not required to qualify for CCEP examination eligibility. Level III training in ICD implantation requires an extensive knowledge of ICD indications and contraindications, and of management of complications; an ability to assess patients for their risk of elevated defibrillation thresholds (DFTs), determine DFTs when appropriate, and manage high DFTs; an understanding of drug- and pacemaker-ICD interactions; and a thorough knowledge of ICD programming, management of ICD malfunction, and postoperative complications. Level III trainees must have an extensive knowledge of left ventricular lead indications and contraindications, management of biventricular pacemaker malfunctions and interactions, and postoperative complications (10).

Cardiac EP is a rapidly evolving field, and the ongoing introduction of new technology can be expected. These new technologies include leadless pacing systems, left atrial appendage exclusion devices, renal denervation procedures, implantable hemodynamic and pressure monitors, and novel methods for arrhythmia mapping. Therefore, although specific requirements for trainees in these new technologies cannot be stipulated, Level III trainees will be expected to attain the same minimum number of supervised procedures recommended for practicing electrophysiologists in the future. In addition, the increase in the number of left ventricular assist devices and the growth of the adult with congenital heart disease population introduce specific, unquantifiable patient-based complexities. Performance of procedures in these special populations may be limited to certain centers that expose trainees to a larger number of these patients.

3.4. Diagnosis and Management of Emergencies and Complications

The nature of procedures performed in the practice of CCEP raises the real possibility of potential complications that range from minor to major, including those that are immediate and life threatening. It is critical that the Level III trainee be proficient at recognizing potential complications for each type of procedure being performed and understand safeguards that must be in place to minimize risk. In addition, the Level III trainee must become proficient at managing acute intraprocedural complications as well as postprocedural complications. Potential complications include death, vascular disruption (e.g., at an access site or during lead extractions), pulmonary emboli, respiratory compromise, stroke, infection (either device-related or not device-related), cardiac perforation with effusion and/or tamponade, hemothorax, pneumothorax, venous thromboses (both those related to CIED implantation and those that are not device related), phrenic nerve paralysis, atrial esophageal fistula (following AF ablation), and air embolism. The Level III trainee must be proficient at managing those complications that can be treated by the electrophysiologist, as well as understanding when additional support is needed from cardiothoracic surgery, interventional cardiology, or anesthesiology. The Level III trainee is expected to follow institutional requirements for reporting complications, present and discuss them at patient safety or quality improvement conferences, and learn from such experiences.

3.5. Diagnosis and Management of Rare Clinical Conditions and Syndromes

A large number of hereditary conditions can be associated with cardiac arrhythmias, and the Level III trainee must be familiar with inherited ion channel disorders such as long QT syndrome, Brugada syndrome, short QT syndrome, and catecholaminergic polymorphic VT as well as with inherited cardiomyopathies that have arrhythmic manifestations including hypertrophic cardiomyopathy, arrhythmogenic right ventricular dysplasia/cardiomyopathy, myotonic dystrophy, other muscular dystrophies, and other types of cardiomyopathies. In addition, numerous autoimmune and inflammatory disorders have potential electrophysiological manifestations. The Level III trainee shall develop clinically applicable knowledge of the basic and clinical sciences that underlie these disorders and apply this knowledge in patient care. The Level III trainee is not expected to be expert in the complete management of patients with these conditions and syndromes but must be able to use information technology or other available methodologies, including consultation with genetic counselors, clinical geneticists, and experts in these conditions, to diagnose and manage affected patients.

3.6. Research and Scholarly Activity

All trainees are expected to carry out scholarly activities and/or research during Level III training in CCEP. Level III training in CCEP may include structured activities designed to support careers in cardiovascular investigation (11). However, not all Level III CCEP trainees are expected to follow this route. During Level III training, the trainee is expected to work with a mentor(s) to develop areas of scholarly achievement. Scholarly activity may include original clinical, basic science, or translational research; quality improvement activities; presentation at institutional, local, regional, or national meetings; and publication of original articles, reviews, chapters, or case reports. In addition, a scholarly approach to answering clinical questions and enhancing patient care through conducting literature reviews should be promoted throughout the fellowship years. Trainees should be encouraged to develop and maintain habits of self-learning, particularly through regular reading of cardiology and CCEP journals and attending appropriate scholarly meetings. Progress in research and scholarly training is assessed by the program director and instructors through evaluation tools such as direct observation, reviewing presentations and manuscripts, and overseeing research activities.

4. Training Requirements

4.1. Development and Evaluation of Core Competencies

Training and requirements in CCEP address the 6 general competencies promulgated by the ACGME and American Board of Medical Specialties and endorsed by the ABIM. These competency domains are: medical knowledge, patient care and procedural skills, practice-based learning and improvement, systems-based practice, interpersonal and communication skills, and professionalism. The ACC has used this structure to define and depict the components of the clinical competencies for cardiology. The curricular milestones for each competency and domain also provide a developmental roadmap for fellows as they progress through various levels of training and serve as an underpinning for the ACGME reporting milestones. The ACC has adopted this format for its competency and training statements, career milestones, lifelong learning, and educational programs.

Table 1 delineates each of the 6 competency domains, as well as their associated curricular milestones for training in CCEP. Included in the table are examples of evaluation tools suitable for assessing competence in each domain. It is expected that all trainees will achieve the Level III competencies listed in the table. In addition, selected Level III competency components designated with an asterisk (i.e., "III*") require additional training beyond the requirements for every trainee. These additional competencies may be obtained during or after the standard CCEP fellowship, depending on the trainee's career focus and the training opportunities available at the trainee's CCEP fellowship program. It is recognized that not all CCEP programs have sufficient volume of lead extraction and/or epicardial VT ablation procedures, for example, to adequately train ≥ 1 CCEP trainee in these skills within a 24-month fellowship. The milestone interval (12 months, 24 months, or additional months) indicates the stage by which the typical trainee will

achieve a particular competency. In recognition of the fact that programs may vary with respect to the sequence of clinical experiences provided to trainees, the time at which various competencies are achieved may also vary. Moreover, although the competency components included in this table should be achieved by all trainees and are appropriate areas for assessment, not every component need be individually assessed in every trainee. Rather, as with all educational activities, assessment is a sampling process that should be tailored to the needs of the individual trainee and program.

4.2. Number of Procedures and Duration of Training

The minimum number of interventional procedures recommended for the 2-year Level III CCEP fellowship training is the consensus formed by review and consideration of published literature applicable to this topic (12–18), previously published competency statements (19,20), COCATS (10,21,22), policies of the ACGME (6) and the ABIM (23), results from a 2015 survey of CCEP training program directors, practice guidelines (24–27), expert consensus documents (28–32), a policy statement (33) relevant to the practice regarding indications and contraindications of these procedures, and the experience and opinions of the members of the writing group. Recommended procedural numbers are summarized in Table 2. The previously published procedural numbers from the American training documents (6,10,19–23,34) and from international societies and organizations are summarized in Table 3 (35–37). It is expected that the training is directed by an appropriately trained and board-certified mentor in an ACGME–accredited program as defined in Section 2.1. The satisfactory completion of such training is documented by the program director.

As indicated in Section 1.2.3, the procedural volumes in this document are based on a judgment about the minimum experience required to provide most trainees with a sufficient variety of clinical situations and to allow faculty enough opportunity to evaluate the trainee's emerging competency. The numbers of procedures necessary to achieve competence should be interpreted as approximate, based on the educational needs and progress of typical trainees in typical programs. Proficiency and outcomes, rather than length of exposure or the exact number of procedures performed, are the dominant criteria for evaluation of competency in the context of educational milestones. In addition, absolute mastery of all aspects of EP is not likely to be achieved on the basis of the fellowship experience alone. For common and straightforward procedures, mastery can occur, but for very complex or infrequently-performed procedures, lower levels of proficiency are anticipated for new graduates. Realistically, full proficiency in advanced techniques may develop only after additional years of experience, as indicated in Table 1.

Significant overlap exists in the rapidly growing fields of interventional EP and CIED procedures; however, there are differences in the acquisition of technical abilities and cognitive skills with respect to different types of arrhythmias and diagnostic and therapeutic interventions. For instance, the technical skills needed for ablation of AF are substantial. These include performance of trans-septal puncture and cannulation of the left atrium; precise manipulation of the catheter for mapping and ablation; identification of the pulmonary vein ostia; adjustment of the energy used for ablation; and the appropriate use of fluoroscopy, radiographic contrast imaging, 3-dimensional mapping systems, and/or intracardiac echocardiography. Concepts related to pacing maneuvers and entrainment are especially important for characterizing the mechanisms of supraventricular arrhythmias or VAs and for determining the point of origin, the location of the AP, and/or the critical zone of conduction. All are important to the success of ablation. CIEDs share many common implantation techniques and requisite knowledge for management; however, defibrillation and antitachycardia pacing testing, cannulation of the coronary sinus for CRT, lead extraction for defective or infected devices, or programming and management of pacemakers versus ICDs requires different skills. Training programs vary in expertise, technology available, and procedural volumes; nevertheless, trainees are expected to develop proficiencies and be well-versed in most EP–related interventional procedures upon completion of a 2-year fellowship. For these reasons, the recommendations for procedural numbers are categorized by supraventricular tachycardia (SVT), atrial flutter and macro–re-entrant AT, AF, VA, CIED implantation, CIED interrogation and programming, and lead extraction. It is recognized that not all trainees will receive training in all aspects of clinical EP and device implantation and management. The core components of EP training that are required of all trainees, as well as those components of EP training that are considered elective and, as a result, are not required to complete a CCEP training program, are presented in Table 1. The proficiencies that are not required for all CCEP trainees include epicardial VT ablation, lead extraction, atrial appendage occlusion/ligation, and catheter ablation of atrial arrhythmias and VAs in patients with complex congenital heart disease.

Each trainee should perform at least 175 electrophysiological procedures for arrhythmia evaluation. These can be performed in conjunction with catheter ablation procedures. Over the 2-year CCEP fellowship, at least 160 ablation procedures should be performed, with at least 50 of these being supraventricular ablation procedures. These ablations should include 5 focal ATs, 5 AV node ablations, 25 AV nodal re-entrant tachycardias, and 15 AV re-entrant tachycardias and other less common SVTs, including sinus node re-entrant tachycardia and junctional tachycardia. The role of the trainee should either be to function as the primary hands-on operator or to perform programmed electrical stimulation and analyze the diagnostic components of the procedure. Expertise in catheter placement, programmed electrical stimulation, endocardial mapping, catheter ablation, and interpretation of data must be ensured by the CCEP faculty and training program director. The endocardial mapping experience should include left heart mapping by either the

Table 1 Competency Components and Curricular Milestones for Level III Training in Clinical Cardiac Electrophysiology

Competency Component		Milestones (Months)		
MEDICAL KNOWLEDGE		12	24	Add
Pathophysiological Basis of Cardiac Arrhythmias/Basic Electrophysiology				
1.	Know normal cardiac anatomy, including the anatomy of the conduction system.	III		
2.	Know basic cardiac electrophysiology.	III		
3.	Know the mechanisms of cardiac arrhythmias, including the relationship between cardiac arrhythmias and structural heart disease (including congenital heart disease), sympathetic as well as parasympathetic tone, myocardial ischemia/infarction, and drugs.		III	
4.	Know the physiology and pathophysiology of the atrioventricular conduction system and the types and associated clinical manifestations of accessory pathways.	III		
5.	Know the genetic basis of arrhythmias, including genetically-based ion channel abnormalities and inherited cardiomyopathies.		III	
6.	Know the epidemiology of arrhythmias.	III		
7.	Know the influence of acquired structural or congenital heart disease in causing cardiac arrhythmias and its effect on clinical decision-making about arrhythmia risk and management.		III	
8.	Know the systemic disorders and metabolic abnormalities associated with arrhythmias and conduction abnormalities.	III		
Diagnostic Tests				
Noninvasive Diagnostic Tests				
9.	Know the role and method of interpreting ECGs obtained during sinus rhythm, exercise, and cardiac arrhythmias in the evaluation of patients with known or suspected cardiac arrhythmias.	III		
10.	Know the methods to interpret surface ECG for the differential diagnosis of cardiac arrhythmias.	III		
11.	Know the indications for event monitors/recorders and Holter monitors/recorders and the methods to interpret the results.	III		
12.	Know the indications for tilt table tests, the methods to perform a tilt table test, and the methods to interpret the results.	III		
13.	Know the role of exercise stress testing, with or without imaging, in the evaluation and management of patients with cardiac arrhythmias.	III		
14.	Know the role of transthoracic and transesophageal echocardiography in the management of patients with cardiac arrhythmias.	III		
15.	Know the role of transesophageal echocardiography and intracardiac echocardiography in guiding trans-septal puncture and ablation near key anatomic structures and monitoring for the development of a pericardial effusion.		III	
16.	Know the role of advanced imaging (computed tomography, magnetic resonance imaging, and positron emission tomography) in the evaluation and management of patients with cardiac arrhythmias.		III	
17.	Know the electrophysiological basis of various electrocardiographic parameters such as signal-averaged electrocardiography.		III	
18.	Know the methods to interpret tracings and other information downloaded from pacemakers, defibrillators, and implanted loop monitors with respect to both arrhythmias and heart failure management.	III		
19.	Know the indications for referring patients for sleep apnea evaluation.	III		
Invasive Electrophysiological Testing				
20.	Know the techniques of, indications for, contraindications, and potential complications of invasive electrophysiological studies.	III		
21.	Know the principles of obtaining vascular access, multielectrode catheter placement, electrogram recording, and stimulation.	III		
22.	Know the invasive laboratory recording techniques, including the principles of amplifiers, filters, and signal processors.	III		
23.	Know the principles of advanced 3-dimensional mapping systems, including anatomical chamber reconstruction, image integration, and creation and interpretation of electroanatomical activation and voltage maps.		III	
24.	Know the principles of radiation safety and of electrical safety (related to fluoroscopy and other equipment used in the laboratory) in the performance of electrophysiology studies, ablation, or device therapy.	III		

Table 1 (*continued*)

Competency Component		Milestones (Months)		
MEDICAL KNOWLEDGE		12	24	Add
25.	Know the characteristics of unipolar and bipolar intracardiac electrocardiographic signals.	III		
26.	Know the methods of programmed electrical stimulation, the role of provocative drug testing/stimulation, and the characteristic findings in patients with and without arrhythmias or conduction disturbances.	III		
27.	Know the pacing protocols to evaluate sinus node and atrioventricular node function and to induce supraventricular and ventricular arrhythmias, including use of entrainment.	III		
28.	Know the predictive value and limitations of invasive electrophysiological studies in patients with various arrhythmias and clinical syndromes.	III		
Nondevice Therapies				
Antiarrhythmic Medications				
29.	Know the indications, contraindications, and clinical pharmacology of antiarrhythmic drugs and sympathetic and parasympathetic agonists and antagonists.	III		
30.	Know the clinical pharmacokinetics and pharmacodynamics of antiarrhythmic medications.	III		
31.	Know the adverse effects of antiarrhythmic drugs, including drug–drug and drug–device interactions and proarrhythmia potential.	III		
Catheter Ablation				
32.	Know the biophysics of radiofrequency, cryoablation, and other ablation energy sources that become available.		III	
33.	Know the indications and contraindications for catheter ablation of all types of cardiac arrhythmias.	III		
34.	Know the complications associated with catheter ablation of all types of cardiac arrhythmias.	III		
35.	Know the methods to minimize the risks of complications of catheter ablation.		III	
36.	Know the methods to manage complications that occur during catheter ablation.		III	
37.	Know the relative benefits and risks associated with radiofrequency ablation, cryoablation, and other ablation technologies that become available.		III	
Surgical Ablation				
38.	Know the pathophysiological basis of arrhythmia surgery.		III	
39.	Know the techniques, indications for, and complications associated with surgical treatment of cardiac arrhythmias, including surgical atrial fibrillation ablation.		III	
Implantable Devices				
Pacemakers				
40.	Know the indications for implantation of a cardiac pacemaker and the methods to select the appropriate pacemaker type for a particular patient.	III		
41.	Know the complications associated with placement of a cardiac pacemaker and the methods to manage those complications.	III		
42.	Know the methods to interrogate, program, and troubleshoot cardiac pacemakers, including the use of remote monitoring and interrogation.	III		
Implantable Defibrillators				
43.	Know the indications for implantation of an implantable cardioverter-defibrillator for primary and secondary prevention of sudden cardiac death.	III		
44.	Know the methods for selecting the appropriate implantable cardioverter-defibrillator type (including subcutaneous implantable cardioverter-defibrillators) for a particular patient.	III		
45.	Know the complications associated with implantation of an implantable cardioverter-defibrillator and the methods to manage them.	III		
46.	Know the methods to interrogate, program, and troubleshoot implantable cardioverter-defibrillators including the use of remote interrogation.	III		
Resynchronization Therapy				
47.	Know the indications for cardiac resynchronization therapy.	III		
48.	Know the complications associated with placement of a cardiac resynchronization therapy device and the methods to manage those complications.		III	

Table 1 (*continued*)

Competency Component		Milestones (Months)		
MEDICAL KNOWLEDGE		12	24	Add
49.	Know the theories and methodology of optimization of cardiac resynchronization therapy as well as the methods to interrogate, program, and troubleshoot cardiac resynchronization therapy.		III	
Implantable Loop Monitors				
50.	Know the indications for and complications of implantable loop monitors and the methods to interpret the recordings.	III		
Left Atrial Appendage Occlusion/Ligation				
51.	Know the indications for left atrial appendage occlusion and appendage ligation.	III		
52.	Know the techniques of and complications associated with left atrial appendage occlusion and appendage ligation.		III	
53.	Know the methods to manage the complications associated with left atrial appendage occlusion and appendage ligation.		III	
Lead Management				
54.	Know the indications for lead extraction and management strategies for infected devices.	III		
55.	Know the complications of lead extraction and the methods to manage them.		III	
56.	Know the methods for diagnosing and managing lead failure.		III	
Arrhythmia Types and Syndromes				
Bradyarrhythmias and Heart Block				
57.	Know the pathophysiological basis of sinus node dysfunction and heart block.	III		
58.	Know the differential diagnosis and approach to diagnosis of patients with heart block, acquired and congenital.	III		
59.	Know the methods to diagnose and manage sinus node dysfunction and heart block, acquired and congenital.	III		
Atrial Fibrillation and Atrial Flutter				
60.	Know the pathophysiological basis of atrial fibrillation and atrial flutter.	III		
61.	Know the methods to diagnose atrial fibrillation and atrial flutter.	III		
62.	Know the methods to assess the risk of stroke and bleeding in patients with atrial fibrillation and atrial flutter.	III		
63.	Know the indications for, complications of, and contraindications to anticoagulation.	III		
64.	Know the pharmacology of anticoagulant drugs, including reversal of actions.	III		
65.	Know when and how to prescribe and monitor anticoagulant drugs.	III		
66.	Know when and how to prescribe rate control medications.	III		
67.	Know when to recommend ablation of the atrioventricular node for rate control.	III		
68.	Know when and how to prescribe antiarrhythmic medications for rhythm control strategies.	III		
69.	Know the indications and techniques for electrical and pharmacological cardioversion.	III		
70.	Know the techniques, risks, and benefits of catheter and surgical ablation of atrial fibrillation and atrial flutter.		III	
71.	Know the methods to manage the complications associated with catheter ablation of atrial fibrillation and atrial flutter.		III	
Other Supraventricular Tachycardias				
72.	Know the pathophysiological basis of atrial tachycardia, junctional tachycardia, atrioventricular nodal re-entrant tachycardia, and accessory pathway-mediated tachycardia and associated risks of each arrhythmia, including sudden cardiac death, heart failure, and stroke.	III		
73.	Know the methods to stratify risk of sudden death in patients with pre-excitation.	III		
74.	Know the methods to diagnose atrial tachycardia, junctional tachycardia, atrioventricular nodal re-entrant tachycardia, and accessory pathway-mediated tachycardia.	III		
75.	Know when and the methods to recommend drug therapy for patients with atrial tachycardia, junctional tachycardia, atrioventricular nodal re-entrant tachycardia, and accessory pathway-mediated tachycardia.	III		
76.	Know the indications for, techniques of, and complications associated with catheter ablation for treatment of patients with atrial tachycardia, junctional tachycardia, atrioventricular nodal re-entrant tachycardia, and accessory pathway-mediated tachycardia.		III	

Table 1 (*continued*)

Competency Component		Milestones (Months)		
MEDICAL KNOWLEDGE		12	24	Add
77.	Know the methods to manage the complications associated with catheter ablation of atrial tachycardia, junctional tachycardia, atrioventricular nodal re-entrant tachycardia, and accessory pathways.		III	
Inherited Arrhythmia Syndromes and Genetic Testing				
78.	Know the pathophysiological basis of arrhythmias that occur in patients with an inherited arrhythmia syndrome/cardiomyopathy.	III		
79.	Know the genetic basis of inherited arrhythmia syndromes/cardiomyopathy.	III		
80.	Know the methods to diagnose inherited arrhythmia syndromes/cardiomyopathy, including the roles and limitations of genetic testing in diagnosis and family screening.		III	
81.	Know the methods to manage patients with inherited arrhythmia syndromes.		III	
82.	Know the indications for pharmacotherapy, ablation, cardiac sympathetic denervation, and device therapy for the treatment of patients with an inherited arrhythmia syndrome/cardiomyopathy.		III	
Ventricular Arrhythmias and Sudden Cardiac Death				
83.	Know the definition and magnitude of the problem of sudden cardiac arrest/death, the methods to manage acute episodes, and the methods to evaluate and treat survivors.	III		
84.	Know the pathophysiological basis of ventricular arrhythmias, including premature ventricular contractions, nonsustained ventricular tachycardia, torsades de pointes, sustained ventricular tachycardia, ventricular fibrillation, pulseless electrical activity, and heart block/asystole.	III		
85.	Know the pathophysiological basis of and the acute and long-term approach to management of patients with aborted sudden cardiac death.	III		
86.	Know the methods of diagnosing and managing patients with premature ventricular contractions, nonsustained ventricular tachycardia, torsades de pointes, ventricular tachycardia, ventricular fibrillation, pulseless electrical activity, and heart block/asystole.	III		
87.	Know when and the methods to recommend drug therapy for patients with ventricular arrhythmias.	III		
88.	Know the indications and techniques for electrical and pharmacological cardioversion and defibrillation.	III		
89.	Know the indications for, techniques for, and complications associated with catheter ablation of ventricular arrhythmias.		III	
90.	Know the methods for determining sudden cardiac death risk and when to advise implantation of an implantable cardioverter-defibrillator in patients with or at risk for development of ventricular arrhythmias.	III		
91.	Know the methods to assess sudden death risk in athletes.	III		
92.	Know the methods to diagnose and manage ventricular arrhythmias in athletes.	III		
Syncope				
93.	Know the differential diagnosis of syncope.	III		
94.	Know the methods for determining the cause of syncope, including the role of the clinical history, ECG, noninvasive arrhythmia monitoring, cardiac imaging, electrophysiology testing, and tilt table testing.	III		
95.	Know the methods for treating patients with syncope, including vasovagal syncope and syncope resulting from cardiac arrhythmias.	III		
Palpitations and Paroxysmal Supraventricular Tachycardias				
96.	Know the differential diagnosis of patients presenting with palpitations and the corresponding methods for diagnosis and treatment.	III		
97.	Know the differential diagnosis of patients with paroxysmal supraventricular tachycardia and the corresponding methods for diagnosis and treatment.	III		
	EVALUATION TOOLS: direct observation, chart-stimulated recall, multisource evaluation, and conference presentation.			

Competency Component		Milestones (Months)		
PATIENT CARE AND PROCEDURAL SKILL		12	24	Add
Patient Consultation and Management				
1.	Skill to perform a comprehensive clinical evaluation (consultation) for patients with manifest or suspected cardiac arrhythmias or conduction disturbance and to establish an appropriate evaluation and management plan in both outpatient and inpatient settings.		III	

Table 1 (*continued*)

Competency Component	Milestones (Months)		
PATIENT CARE AND PROCEDURAL SKILL	12	24	Add
2. Skill to evaluate and manage patients in the intensive care and postoperative electrophysiology procedural and surgical care units.		III	
Diagnostic Tests			
Noninvasive Diagnostic Tests			
3. Skill to appropriately utilize and perform noninvasive testing in the evaluation and management of patients with arrhythmias.	III		
4. Skill to appropriately utilize electrocardiography in the evaluation and management of patients with cardiac arrhythmias and inherited arrhythmia syndromes.		III	
5. Skill to appropriately utilize and perform exercise stress testing in the evaluation and management of patients with arrhythmias.	III		
6. Skill to appropriately utilize transthoracic and transesophageal echocardiography in the evaluation and management of patients with arrhythmias.	III		
7. Skill to appropriately utilize and perform intracardiac echocardiography in the evaluation and management of patients with arrhythmias.		III	
8. Skill to appropriately utilize advanced imaging (cardiovascular computed tomography, cardiovascular magnetic resonance, and positron emission tomography) in the evaluation and management of cardiac arrhythmias.		III	
Invasive Electrophysiological Evaluation			
9. Skill to place sheaths in the femoral, internal jugular, subclavian, axillary, and cephalic veins using anatomic landmarks and ultrasound imaging.	III		
10. Skill to place sheaths in the femoral arteries using anatomic landmarks and ultrasound imaging.	III		
11. Skill to place and manipulate electrode catheters in the atria, ventricles, coronary sinus, His bundle area, aortic root, and pulmonary artery.	III		
12. Skill to accurately measure and assess conduction intervals and refractory periods during programmed electrical stimulation.	III		
13. Skill to use intracardiac recordings to determine activation sequence mapping and to interpret the responses to pacing techniques including entrainment.		III	
14. Skill to use advanced 3-dimensional mapping systems, including anatomical chamber reconstruction, image integration, and electroanatomical activation and voltage maps in the management of patients with cardiac arrhythmias.		III	
15. Skill to appropriately utilize and monitor sedation during procedures.	III		
16. Skill to identify patients in whom general anesthesia should or should not be considered for electrophysiology and device procedures.	III		
17. Skill to recognize and manage procedural complications, including vascular complications, cardiac perforation/tamponade, pneumothorax, lead dislodgements, and pocket complications (e.g., bleeding, infection).		III	
18. Skill to appropriately select patients for electrophysiology procedures and effectively carry out preprocedural, intraprocedural, and postprocedural management and follow-up.	III		
19. Skill to integrate the findings from invasive electrophysiological testing with clinical and other testing results in the management of patients with arrhythmias or conduction disturbances.		III	
20. Skill to apply diagnostic pacing maneuvers to distinguish among different forms of supraventricular tachycardia and in assessment of ventricular tachycardia.		III	
21. Skill to perform and interpret invasive electrophysiological testing in patients with all forms of arrhythmias, including AV nodal re-entrant tachycardia, atrial tachycardia or flutter, atrioventricular node or accessory pathway abnormalities, and ventricular arrhythmias.		III	
Nondevice Therapies			
Antiarrhythmic Medications			
22. Skill to prescribe antiarrhythmic drug therapy for treatment of patients with cardiac arrhythmias.	III		
23. Skill to monitor patients being treated with antiarrhythmic drug therapy.	III		

Table 1 (*continued*)

Competency Component	Milestones (Months)		
PATIENT CARE AND PROCEDURAL SKILL	12	24	Add
24. Skill to manage patients with a pro-arrhythmic response to antiarrhythmic drug therapy or side effects to antiarrhythmic drugs.	III		
Catheter Ablation			
25. Skill to carry out ablation therapy in patients with atrioventricular nodal re-entrant tachycardia, atrial tachycardia, typical atrial flutter, and accessory pathway–mediated arrhythmias.		III	
26. Skill to carry out ablation therapy in patients with atrial fibrillation.		III	
27. Skill to carry out ablation therapy in patients with atypical atrial flutter.		III	
28. Skill to carry out ablation therapy in patients with idiopathic premature ventricular contractions and/or ventricular tachycardia arising from right ventricular outflow tract.		III	
29. Skill to carry out ablation therapy in patients with idiopathic premature ventricular contractions and/or ventricular tachycardia arising from sites other than the right ventricular outflow tract.		III	
30. Skill to identify appropriate candidates for and assess risk/benefit of epicardial approach to ventricular tachycardia ablation.			III
31. Skill to carry out epicardial ventricular tachycardia ablation.			III
32. Skill to introduce sheaths and catheters into the left atrium via a patent foramen ovale or trans-septal puncture to perform mapping and ablation.		III	
33. Skill to access the aortic root and/or left ventricle using a retrograde aortic approach.		III	
34. Skill to utilize magnetic resonance imaging, computed tomography, and intracardiac echocardiography to facilitate invasive electrophysiology testing, intracardiac mapping, and catheter ablation.		III	
35. Skill to effectively perform ablation for scar-based atrial and ventricular arrhythmias.		III	
36. Skill to perform invasive electrophysiology studies and ablation therapy in adult patients with repaired or unrepaired congenital heart disease.			III*
37. Skill to recognize and manage patients who experience a complication during and/or following catheter ablation.		III	
38. Skill to minimize the risks of complications associated with catheter ablation.		III	
Surgical Ablation			
39. Skill to identify patients likely to benefit from surgical treatment of cardiac arrhythmias.		III	
40. Skill to follow patients who have undergone surgical treatment of a cardiac arrhythmia.		III	
Implantable Devices			
Pacemakers			
41. Skill to appropriately select, implant, test, interrogate, program, and follow pacemakers.	III		
42. Skill to identify and manage complications associated with pacemaker implantation.	III		
Implantable Cardioverter-Defibrillators			
43. Skill to appropriately select, implant, test, interrogate, program, and follow implantable cardioverter-defibrillator devices in clinic and remotely.	III		
44. Skill to identify and manage complications associated with placement of implantable cardioverter-defibrillators.		III	
45. Skill to identify appropriate patients for, and to implant, subcutaneous implantable cardioverter-defibrillators.		III	
Resynchronization Therapy			
46. Skill to appropriately select, implant, test, interrogate, program, and follow cardiac resynchronization therapy devices.		III	
47. Skill to identify and manage complications associated with cardiac resynchronization therapy device implantation.		III	
Implantable Loop Recorders			
48. Skill to implant implantable loop recorders.	III		
49. Skill to interrogate and follow patients who have undergone implantable loop recorder implantation.	III		
Left Atrial Appendage Occlusion/Ligation			
50. Skill to perform placement of a left atrial appendage occlusion device, including recognition and management of complications.			III*
51. Skill to perform left atrial appendage ligation using a percutaneous approach, including recognition and management of complications.			III*

Table 1 (*continued*)

Competency Component	Milestones (Months)		
PATIENT CARE AND PROCEDURAL SKILL	12	24	Add
52. Skill to identify patients who are candidates for surgical left atrial appendage ligation and to follow these patients following the procedure.		III	
Lead Management			
53. Skill to identify anatomic lead location on the basis of fluoroscopic or x-ray image.	III		
54. Skill to perform lead extraction.			III*
55. Skill to manage patients with lead failure.		III	
56. Skill to manage patients with a device infection.		III	
Arrhythmia Types and Syndromes			
Bradyarrhythmias and Atrioventricular Block			
57. Skill to diagnose and manage patients with bradyarrhythmias, including sinus node dysfunction, asystole, and heart block.	III		
Atrial fibrillation and Atrial Flutter			
58. Skill to diagnose and manage patients with atrial fibrillation, including anticoagulation and rate and rhythm control.	III		
59. Skill to perform electrical and pharmacological cardioversion.	III		
Other Supraventricular Arrhythmias			
60. Skill to diagnose and manage patients with supraventricular tachycardia, including with pharmacological therapy and catheter ablation.		III	
Inherited Arrhythmia Syndromes and Genetic Testing			
61. Skill to diagnose, manage, or refer patients with an inherited arrhythmia syndrome/cardiomyopathy to physicians/programs who have this expertise.		III	
62. Skill to know when to order genetic testing.		III	
63. Skill to interpret the results of genetic testing with the assistance of a genetic counselor.		III	
Ventricular Arrhythmias and Sudden Cardiac Death			
64. Skill to evaluate and manage patients at risk for sudden cardiac arrest or aborted sudden cardiac arrest.	III		
65. Skill to evaluate and manage patients with ventricular arrhythmias, including premature ventricular contractions, nonsustained ventricular tachycardia, torsades de pointes, sustained ventricular tachycardia, and ventricular fibrillation.		III	
66. Skill to perform electrical and pharmacological cardioversion and defibrillation.	III		
Syncope			
67. Skill to evaluate and manage patients with syncope.	III		
Palpitations and Paroxysmal Supraventricular Tachycardias			
68. Skill to evaluate and manage patients with palpitations and paroxysmal supraventricular tachycardia.	III		
EVALUATION TOOLS: chart-stimulated recall, clinical and patient safety and quality improvement conference presentation, direct observation, multisource evaluation, and logbook, simulation.			
SYSTEMS-BASED PRACTICE	12	24	Add
1. Use hospital data and available registries to assess appropriateness, performance, and safety of implanted devices.		III	
2. Work effectively with hospital electrophysiology laboratory staff to enhance safety and efficiency while controlling cost.		III	
3. Incorporate risk/benefit analysis and cost considerations in diagnostic and treatment decisions.		III	
4. Work as part of a multidisciplinary team to provide safe and effective transitions of care within and across healthcare systems.	III		
EVALUATION TOOLS: chart-stimulated recall, direct observation, and multisource evaluation.			
PRACTICE-BASED LEARNING AND IMPROVEMENT	12	24	Add
1. Identify knowledge and performance gaps and engage in opportunities to achieve focused education and performance improvement.		III	

Table 1 (*continued*)

Competency Component	Milestones (Months)		
PATIENT CARE AND PROCEDURAL SKILL	12	24	Add
2. Know how to conduct literature searches and apply results to clinical care.	III		
3. Develop practice of lifelong learning, including regular review of cardiology and clinical cardiac electrophysiology journals and attending appropriate scholarly meetings.		III	
4. Learn and improve via feedback and performance audit.		III	
EVALUATION TOOLS: chart-stimulated recall, conference presentation, logbook, and self-reflection.			
PROFESSIONALISM	12	24	Add
1. Practice within the scope of personal expertise and technical skills.		III	
2. Demonstrate sensitivity to patient preferences and end-of-life decisions.	III		
3. Accept responsibility and follow through on tasks.		III	
EVALUATION TOOLS: chart-stimulated recall, conference presentation, direct observation, and self-reflection.			
INTERPERSONAL AND COMMUNICATION SKILLS	12	24	Add
1. Communicate effectively with patients, families, and interprofessional teams across a broad range of cultural, ethnic, and socioeconomic backgrounds including those from underserved communities.	III		
2. Engage in shared decision-making with patients, including options for diagnosis and treatment.		III	
3. Provide test results and interpretations to healthcare providers and patients in a timely fashion.	III		
EVALUATION TOOLS: direct observation and multisource evaluation.			

Add indicates additional training beyond the standard 2-year CCEP fellowship and ECG, electrocardiogram.

*Given the complex and highly skilled nature of these competencies, additional focused training and experience is required either during or following the 2-year CCEP fellowship.

retrograde aortic or trans-septal approach for APs. Training in trans-septal catheterization for performance of AF ablation and for ablation of arrhythmias originating from the left atrium or involving left APs is required. These numbers should not be regarded as strict requirements but rather as a general framework of the depth and breadth of exposure that trainees should obtain during their training. Earlier data from multicenter surveys suggest that procedural complications were significantly associated with procedural volumes. From the Multicenter European Radiofrequency Survey (15), complication rates of 4.6% were reported from centers with $\geq$100 cases/year, compared with 5.6% from centers performing $\leq$50 cases/year. From a 1994 survey from the North American Society of Pacing and Electrophysiology (14), a 1.5% complication rate was reported from centers performing $\geq$50 cases/year, whereas complications occurred in 3.2% of patients from centers performing $\leq$20 cases/year. The success rate of AP ablation was related to the operator's experience.

The patient population with typical atrial flutter and other macro–re-entrant AT is growing, primarily related to increasing surgical and ablation procedures in the atria. Each trainee should participate in mapping and ablation of at least 30 of these arrhythmias. Achieving competence in programmed electrical stimulation with cognitive skills in identifying the arrhythmia circuit using both activation and entrainment mapping, determining appropriate sites for ablation, and demonstrating conduction block across re-entry circuit sites post-ablation is expected. Integration of knowledge related to 3-dimensional mapping systems and re-entrant mechanisms is required. Although it is unlikely that trainees will be exposed to all mapping technologies during their 2 years of training given the rapid evolution of new mapping technologies, trainees should be exposed to tools for definition of intracardiac anatomy, such as intravascular ultrasound, CMR, CT, and advanced mapping systems. Of the 30 procedures, at least 20 typical atrial flutters and 10 other macro–re-entrant ATs are expected. It is anticipated that postgraduate education will continue after the 2 training years.

AF ablation is the most commonly performed catheter ablation procedure today. The procedure is complex, requiring technical ability and dexterity, an in-depth understanding of anatomical relationships, and integration of cognitive skills. Each trainee should participate in at least 50 AF ablation cases. Although the standardization of the technical approach continues to evolve (25,26,31), improved outcomes have been associated with centers that perform at

Table 2 Recommendations for Minimum Procedural Volume to Achieve and Demonstrate Competence in Clinical Cardiac Electrophysiology

Procedures	Numbers*
Diagnostic electrophysiology studies (which can be performed with catheter ablation procedures)	175
Catheter ablation procedures	160
SVT (not including atrial fibrillation or flutter)	50
Focal AT	5
AVN	5
AVNRT	25
AVRT/AP	15
Atrial flutter/macro–re-entrant AT	30
Isthmus dependent atrial flutter	20
Nonisthmus dependent/complex macro–re-entry atrial arrhythmias	10
Atrial fibrillation	50
VT/PVC ablation	30
Idiopathic VT/PVCs	20
VT/PVCs in patients with SHD	10
CIED procedures	
CIED implantation	100
Pacemakers	40†
ICDs	60†
CRT pacemakers or ICDs	25‡
CIED replacement/revision	30
CIED interrogation/programming	200
CIED interrogation/programming, pacemakers	100
CIED interrogation/programming, ICDs	100
Remote device interpretation§	50
Lead extraction procedures‖ (with one or more leads implanted >12 months previously)	30
Tilt table tests	5

AP indicates accessory pathway; AT, atrial tachycardia; AVN, atrioventricular node; AVNRT, atrioventricular nodal re-entrant tachycardia; AVRT, atrioventricular reciprocating tachycardia; CIED, cardiac implantable electrical device; CRT, cardiac resynchronization therapy; ICD, implantable cardioverter-defibrillator; PVC, premature ventricular contraction; SHD, structural heart disease; SVT, supraventricular tachycardia; and VT, ventricular tachycardia.

*Actual numbers that should be performed and/or interpreted successfully to achieve competence are intended as general guidance, based on the educational needs and progress of typical CCEP trainees.

†Of which at least 20 should be dual chamber.

‡Also count as pacemaker or implantable cardioverter-defibrillator implants.

§The remote interrogations can be included as CIED interrogation/programming number requirements.

‖Lead extraction is a special competency not expected of all CCEP trainees.

least 100 ablation procedures annually (12,16–18). Complications are also related to procedural volumes. Data from the National Inpatient Sample (13) showed that procedural complication rates were significantly lower among operators performing ≥50 AF ablations/year compared with ≤25 cases/year. Lower complication rates occurred in hospitals that performed at least 100 cases/year compared with those that performed <50 cases/year.

Fellowship training on ablation of VAs is important. Each trainee should participate in at least 30 ablation procedures for VA. Ablation of VAs requires a wide spectrum of technical skills and understanding of anatomy, as it may require mapping of right ventricular and left ventricular endocardium, the great vessels including the aortic root and venous structures, and/or the epicardium. The substrate for re-entrant VT occurs in both ischemic heart disease and nonischemic heart disease. Due to the wide spectrum of VA location and substrate, it is recommended that experience should include 20 VAs of the idiopathic type and 10 VAs in patients with structural heart disease. In addition to developing expertise in electroanatomic mapping, fellows must have exposure to the advanced ablation delivery systems. Due to the thickness of the ventricular myocardium, technical proficiency in accessing epicardial space and positioning catheters in cardiac venous vasculature is of value in selected cases. Becoming expert in these evolving techniques is not required of all EP trainees and, if desired, may necessitate that the trainee obtain additional training in centers specializing in these procedures.

CIED training must include development of expertise in permanent atrial and right and left ventricular pacemaker lead placement and ICD lead placement, threshold testing and programming of devices, understanding of CIED infections, and management of implant-related complications. Individuals receiving qualifying training in CIED implantation must participate as the primary operator (under direct supervision) in at least 100 CIED initial primary implantations, of which 25 should be CRT device implantations. Primary implantations should include at least 40 pacemakers (20 dual chamber), 60 ICDs (20 dual chamber), and 25 CRT devices (either pacing or defibrillation). Thirty CIED revisions or replacements are also required. The trainee must also participate in the follow-up of at least 200 CIED patient visits and acquire proficiency in advanced CIED electrocardiography, interrogation, and device programming. Of the follow-up visits, at least 100 should be in ICD and 100 in pacemaker patients. Interpretation of at least 50 remote device monitoring recordings is required. As part of the training regarding CIEDs, exposure to the indications, implantation techniques, and follow-up of loop recorders is desirable.

CIED lead extraction is a specialized procedure that requires special training. Physicians being trained in lead extraction should perform at least 30 lead extraction procedures under the direct supervision of a skilled and experienced physician in this procedure. Each of these 30 procedures should involve removal of ≥1 lead that had been implanted for 12 months or longer.

Tilt table testing is useful for the evaluation of syncope and for the understanding of the physiology or pathophysiology of vasovagal response and orthostatic intolerance. During the CCEP fellowship, a trainee should conduct at least 5 tilt table tests.

4.3. Diagnostic Testing

4.3.1. Noninvasive Diagnostic Tests

Numerous tests are available to evaluate the electrophysiological properties of the heart. Although learning the fundamentals of ECG is part of the basic knowledge requirements for general cardiology, promulgating a deeper understanding of the electrophysiological fundamentals that are manifest in ECG recordings is critical in electrophysiological training. A

Table 3 History of Societal Recommendations for Training to Achieve Competence in Clinical Cardiac Electrophysiology

	CCEP Procedures, n											
Source	EP Studies*	SVT Ablation	Atrial Flutter/ Macro–Re-Entrant AT	Atrial Fibrillation	Ventricular Arrhythmia	CIED Interrogation/ Programming	CIED Implantation	Pacemaker	ICD	CRT	CIED Replacement/ Revision	Lead Extraction
ACP/ACC/ AHA 1994 (19)	100	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
ACC/AHA 2006 (20)	150	50–75	NS	30–50	NS	NS	NS	NS	NS	NS	NS	NS
COCATS 1995 (21)	100	50	NS	NS	NS	NS	50	NS	NS	NS	NS	NS
COCATS 2008 (10)	150	75	NS	30–50	NS	200	75†	25	25	25	30	20
ACGME 2016 (6)	150–175	75	NS	NS	NS	NS	NS	25‡	25	25	NS	NS
ABIM 2014 (23)	150	75	NS	NS	NS	NS	25	NS	NS	NS	NS	NS
British Cardiac Society 1995 (35)	70	50	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CCS/CHRS 2011 (37)	100–150	50	10–20§	30–50	10–20‖	NS	75	NS	25	15	20	NS
EHRA 2009 (36)¶	200 (50)	150 (35)	NS	NS	NS	NS	NS	50 (30)	30 (15)	20 (10)	NS	NS

ABIM indicates American Board of Internal Medicine; ACC, American College of Cardiology; ACGME, Accreditation Commission for Graduate Medical Education; ACP, American College of Physicians; AHA, American Heart Association; CCS, Canadian Cardiovascular Society; CHRS, Canadian Heart Rhythm Society; COCATS, Core Cardiovascular Training Statement; EHRA, European Heart Rhythm Association; EP, electrophysiology; ICD, implantable cardioverter-defibrillator; n, number; NS, not specified; other abbreviations as in Table 2.

*Including ablation.

†25 dual-chamber CIEDs are required.

‡Dual chamber.

§Macro–re-entrant AT.

‖Scar-dependent.

¶Total procedures (as the primary operator).

series of professional multisocietal documents provides information on standardized interpretation and reporting of the surface 12-lead ECG (38–43). Similarly, although evaluation of ambulatory ECG monitoring is part of the basic cardiology curriculum, a more nuanced interpretation is a critical skill for electrophysiologists and often provides insight into arrhythmia mechanism. For certain groups, such as athletes, additional and more focused electrocardiographic education and knowledge are required. Ambulatory ECG monitoring techniques have evolved rapidly over the past decade, and the electrophysiologist must understand the relative benefits of different monitoring technologies with particular focus on the cost, benefit, and recommended duration of different monitoring periods. Some specialized tests including the signal-averaged ECG, T-wave alternans, body surface mapping, tilt table testing, and autonomic testing may not be in widespread clinical use. However, understanding the electrophysiological basis for these tests remains an essential component of EP training, particularly in estimating the risk of sudden cardiac arrest/death in selected patients (44–46).

Tilt table testing and treadmill testing can provide valuable information for patients with orthostatic or exercise-related symptoms or arrhythmias. In addition to provocative tests designed to evaluate electrophysiological properties of the heart in different conditions, EP training must include a discussion of the full range of cardiovascular stress testing techniques. For example, stress testing used to identify the presence of significant coronary artery disease is often important for evaluating the relationship between ischemia and arrhythmia development in individual patients. Stress testing is also important in determining the presence of exercise-related arrhythmias.

Finally, noninvasive tests that allow imaging of the heart have emerged as a critically important component of EP training because of the close relationship between cardiac anatomy and electrophysiological abnormalities. An understanding of the application of techniques such as echocardiography (transthoracic, transesophageal, and intracardiac), cardiovascular CT, CMR imaging, and nuclear studies in the setting of arrhythmias is essential.

4.3.2. *Invasive Electrophysiological Evaluation*

Understanding the indications, risks, and performance of invasive EP studies is a fundamental aspect of advanced training in EP. The CCEP trainee should be able to describe the indications for invasive EP evaluation, perform and interpret a comprehensive EP study, create and interpret an electroanatomic map, and integrate these findings into a formal diagnosis and treatment plan including an ablation strategy when indicated. This includes basic knowledge of recording techniques such as principles of amplifiers, filters, signal processing, mapping techniques, and radiation safety. It also includes the ability to independently perform the appropriate selection of catheters; proper placement; mastery of appropriate pacing protocols; and the ability to induce, terminate, and evaluate the mechanisms of SVTs and VAs.

4.4. Arrhythmia Types and Syndromes

4.4.1. *Pathophysiological Basis of Cardiac Arrhythmias/ Basic Electrophysiology*

The "HRS Policy Statement: Clinical Cardiac Electrophysiology Fellowship Curriculum: Update 2011" was developed by EP fellowship directors as a compendium of the basic information necessary for the practicing electrophysiologist (33). The curriculum recommended in this document provides a useful framework for developing a CCEP fellowship curriculum and emphasizes the importance of understanding basic EP (under both normal conditions and disease states) and cardiac anatomy. Important anatomic concepts identified by the document include an understanding of anatomy of the heart with a particular focus on tissues responsible for the normal heart beat (the sinus node, AV node, His bundle and branches), as well as an understanding of the anatomy of the cardiac vascular system, great vessels, and autonomic nervous system. Basic EP understanding requires comprehensive knowledge of the resting membrane potential and action potential for different cardiac tissues as well as an understanding of the molecular, cellular, and tissue basis for heart arrhythmias. In addition to knowledge of arrhythmias in an individual patient, EP training also requires an understanding of arrhythmias at a population level, including overall incidence and prevalence and strategies that can be employed to treat arrhythmias in groups of people.

As emphasized by Table 1, EP abnormalities can develop in specific conditions such as genetic disorders, congenital heart disease, metabolic abnormalities, and systemic diseases. Competency in EP requires an understanding of arrhythmia issues that develop in these and other conditions.

4.4.2. *Inherited Arrhythmia Syndromes and Genetic Testing*

Heart rhythm specialists are often involved in the initial diagnosis of patients with inherited arrhythmia syndromes and, in many cases, may manage patients with these conditions longitudinally. The trainee must understand the pathophysiological basis of arrhythmias that occur in patients with an inherited arrhythmia syndrome, the ECG findings and other diagnostic features of the syndromes, and the prognosis. The trainee should know the appropriate indication for and limitations of genetic testing and family screening and be familiar with the role of genetic counseling both prior to obtaining genetic tests and in interpreting the test results. The trainee must know the methods to manage these patients including: 1) risk stratification for sudden cardiac death; 2) the indications, efficacy, and limitations of pharmacotherapy; 3) the role of cardiac sympathetic denervation; 4) the indications for device therapy; and 5) recommendation of activity levels, exercise, and participation in competitive sports appropriate to the risks of the inherited disease state.

4.4.3. *Bradyarrhythmias*

Bradyarrhythmias can be broadly classified as those resulting from abnormal automaticity (usually due to sinus node

dysfunction), and those resulting from AV block. EP training should include instruction on the epidemiology, natural history, etiology, anatomy, pathophysiology, and treatment options for both sinus node dysfunction and AV block. For sinus node dysfunction, the different clinical manifestations (e.g., sinus pause or exit block, bradycardia-tachycardia syndrome, chronotropic incompetence), the strengths and limitations of different diagnostic strategies (both invasive and noninvasive), and appropriate use of pacing therapy must be understood. Management of AV block requires an understanding of different clinical manifestations, diagnostic clues and strategies for identifying the anatomic site of block (AV node versus infranodal), the importance of associated conditions (e.g., the patient with AV block due to sarcoidosis, the patient with AV block and neuromuscular disease), and appropriate use of CIED therapy (single- versus dual-chamber pacing, special programming algorithms to minimize ventricular pacing, CRT, and defibrillator capabilities).

4.4.4. Palpitations and Paroxysmal SVTs

Heart rhythm specialists are frequently involved in the initial or ongoing diagnosis of individuals with unspecified palpitations including suspected paroxysmal SVT. Trainees should understand the differential diagnosis of palpitations, including sustained versus nonsustained arrhythmias, atrial arrhythmias versus VAs, and arrhythmic versus nonarrhythmic etiologies. Trainees should develop approaches for evaluating patients with palpitations and suspected arrhythmias, including appropriately selecting diagnostic modalities such as ECG, ambulatory monitors, exercise stress testing, and EP testing. Trainees should understand the indications for treatment of palpitations and paroxysmal SVT at various stages of diagnosis, including observation, lifestyle modification, medications, and catheter ablation.

4.4.5. Supraventricular Tachycardias

The trainee must understand the mechanisms and methods of initiation of different SVTs including ATs, AV nodal reentrant tachycardia, AP-mediated tachycardias, and junctional tachycardias. The trainee must be able to perform and interpret pacing and mapping techniques to differentiate various forms of SVT including pacing maneuvers and interpretation of drug effects as well as physical maneuvers. The trainee must also gain knowledge in the role and selection of pharmacological therapy to treat SVTs. Knowledge of the techniques, indications, and risks of catheter ablation of SVT must also be acquired. This includes experience with 3-dimensional mapping techniques; techniques for retrograde and trans-septal access; and understanding the underlying anatomy, potential complications, and methods to avoid complications.

4.4.6. AF and Atrial Flutter

Comprehensive knowledge of the epidemiology, anatomy, and multifactorial pathophysiology of AF and atrial flutter is essential for CCEP training. It is now evident that patients with atrial arrhythmias represent a diverse group with significant differences in underlying mechanisms and symptoms. It is important that trainees understand the relationship among sleep apnea, obesity, and AF as the relationship concerns both etiology as well as management decisions. The electrophysiologist must have a clear understanding of the natural history of atrial arrhythmias; potential consequences of increased risk for outcomes such as stroke, dementia, cardiomyopathy, heart failure, sudden death, and hospitalizations; and the likelihood of 1 of these adverse outcomes in an individual patient. In particular, the trainee should be familiar with the important and extensive evidence base for the association of atrial arrhythmias and increased risk of stroke and proven therapeutic strategies that can reduce stroke risk in many patients. For oral anticoagulant therapy, an understanding of the individual patient at risk and the different mechanisms and pharmacology of the specific agents that can reduce stroke risk is essential. In addition, appropriate application of this information to an individual patient is essential because the electrophysiologist is often asked to provide a nuanced opinion on best anticoagulant management in difficult cases in patients who are not well represented in clinical trials.

Atrial arrhythmias can be treated with either a rate control or rhythm control strategy (25). Electrophysiologists must have a comprehensive knowledge of the risks, benefits, and limitations of rate control and rhythm control strategies and be able to explain the risks, benefits, and alternatives to patients and their caregivers in a clear and balanced manner. Initial and serial evaluation of AF will often require diagnostic tests to evaluate arrhythmia burden, adequacy of rate control, and identification of associated cardiac and noncardiac diseases or problems. The best diagnostic strategy often varies from patient to patient. In deciding on a treatment plan, the electrophysiologist must understand and consider different drug therapies, catheter ablation procedures, and surgical options (25,31). The mechanisms of action, metabolism, risks, and pharmacology of both rate control and rhythm control medications are an important part of the core curriculum for EP training. The electrophysiologist must be aware of the risks, benefits, and potential adverse outcomes of catheter ablation, surgical procedures, and device therapy in patients with AF. EP training should emphasize the importance of individualized patient-centered care and longitudinal care over extended periods of time. In addition, treatment options for AF are evolving rapidly, and an effective EP training program must have a mechanism to integrate these changes into teaching and clinical practice.

4.4.7. VAs and Sudden Cardiac Death

Advanced training in EP includes the development of a comprehensive understanding of the epidemiology, etiology, and mechanisms of VAs and management of patients with VAs or who are at risk for sudden death due to VT and ventricular fibrillation. This includes an understanding of the

definition and magnitude of the problem of sudden cardiac death. Trainees must understand the pathophysiological basis and diagnostic and management approaches to patients with VAs, including ventricular premature complexes, nonsustained VT, torsades de pointes, sustained VT, and ventricular fibrillation as well as management of patients resuscitated from and at risk for sudden cardiac death. The trainee must also know how to manage VAs in a broad range of patient populations, including athletes.

Topics that must be mastered include the pathophysiological and genetic basis of inherited arrhythmia syndromes such as long QT syndrome; short QT syndrome; catecholaminergic polymorphic VT; and J-wave syndromes, including Brugada syndrome and early repolarization. The trainee must also understand the concepts of arrhythmia pathophysiology, risk stratification, and management. This will include the assessment and management of patients with cardiomyopathies of either ischemic or nonischemic origin, or other cardiomyopathies, such as hypertrophic cardiomyopathy, arrhythmogenic right ventricular cardiomyopathy, sarcoidosis, amyloidosis, and other infiltrative cardiomyopathies. Trainees should understand when to refer a patient/family to a cardiac geneticist and/or an inherited heart disease center for further evaluation and management. The trainee should also understand the significance of congenital heart disease in causing cardiac arrhythmias and risk of sudden death, including the effect on clinical decision making for patient management. There must be a rigorous understanding of the pivotal ICD trials for both primary and secondary prevention of sudden cardiac death. Trainees must understand the principles of arrhythmia genesis and understand potential proarrhythmic effects due to drugs, autonomic influences, myocardial ischemia, and electrolyte abnormalities.

The trainee must learn to direct and carry out appropriate testing to diagnose and risk stratify patients. This includes directing diagnostic testing such as imaging (transthoracic and transesophageal echocardiography, CT, and CMR) for the presence of structural heart disease, exercise testing, and coronary angiography. The trainee must also understand the appropriate use of genetic testing, including family testing for inherited arrhythmia syndromes and cardiomyopathies, and be able to interpret results with the assistance of a genetic counselor. Additionally, the trainee must understand the indications for and be able to interpret other noninvasive testing (i.e., signal-averaged ECG, short- and long-term ECG monitoring, provocative pharmacological testing) and carry out invasive arrhythmia testing when appropriate (i.e., programmed stimulation).

Management of VAs must be mastered in both the acute and chronic settings and tailored to the patient's individual clinical needs and type of VA. This includes the use of drugs (antiarrhythmic and sympathetic/parasympathetic modulators) with an understanding of their pharmacodynamic and pharmacokinetic effects and the potential for drug–drug and drug–device interactions in the treatment of patients with premature ventricular complexes, nonsustained VT, torsades de pointes, VT, and ventricular fibrillation. The trainee must understand the indications for cardiac sympathetic denervation in primary arrhythmia syndromes/cardiomyopathies. The trainee must also understand the indications for, technique of, and complications associated with catheter ablation for treatment of patients with premature ventricular complexes, nonsustained VT, VT, and ventricular fibrillation triggers. The trainee must also know when to advise implantation of an ICD following the assessment of sudden cardiac death risk in patients with VAs and various cardiac diseases.

4.4.8. Syncope

The trainee must acquire the medical knowledge and clinical skills to diagnose and manage patients with syncope. This will include knowledge of the differential diagnosis; approach to diagnosis; and approach to treatment, including risk stratification of patients with syncope.

The trainee will gain an understanding of the classifications of syncope, including vasovagal or neurally-mediated syncope (47), and syncope due to a cardiac arrhythmia, including bradyarrhythmias (sinus bradycardia, AV block) and tachyarrhythmias (SVT and VT). This understanding also includes an appreciation of whether the syncope patient is at risk for sudden cardiac death, such as in the setting of structural heart disease or an inherited arrhythmia syndrome. The trainee will also learn how to evaluate patients with a thorough history, physical examination, and ECG interpretation and to direct appropriate testing for possible structural heart disease or inherited arrhythmia syndrome when indicated. Additionally, the trainee will know the indications for other diagnostic modalities such as short- and long-term ECG monitoring (including ILRs), tilt table testing, and invasive electrophysiological testing.

The trainee must learn to manage patients with neurally-mediated syncope (i.e., vasovagal syncope), including the use of lifestyle measures, pharmacological therapies, nonpharmacological interventions (e.g., lower-body compression garments), and the appropriate indications for permanent pacing. The trainee will also learn how to manage patients with syncope due to cardiac arrhythmias, including the indications for permanent pacing for bradyarrhythmias, and the use of pharmacological therapy and ablation for specific tachyarrhythmias. The trainee must have an understanding of unusual causes of syncope and also know the causes of postural intolerance, such as postural orthostatic tachycardia syndrome, dysautonomias, and orthostatic hypotension. Finally, the trainee must understand how to identify patients at risk for sudden cardiac death for which an ICD or other therapies may be indicated.

4.5. Nondevice Therapies

4.5.1. Antiarrhythmic Medications

The CCEP trainee should know and understand basic concepts for therapeutic drug delivery of antiarrhythmic medications including pharmacokinetic and pharmacodynamic properties.

The trainee should have a thorough understanding of the indications, contraindications, and dosages of commonly used antiarrhythmic medications, including knowledge of drug–drug and drug–device interactions, as well have an understanding of how drug effects and toxicities can differ in specific populations of patients depending on their age, sex, renal function, and drug metabolism. The trainee should also have an understanding of how to follow patients for development of drug side effects and toxicities.

4.5.2. Catheter Ablation

Catheter ablation is an important component of advanced fellowship training in CCEP, allowing effective treatment for many cardiac arrhythmias. The trainee should acquire a thorough understanding of the basic biophysics of radiofrequency, cryoablation, and other ablative energy sources, including the factors that influence how to modify variables that affect ablation lesion size and safety. This includes an in-depth understanding of how to recognize and prevent complications from catheter ablation.

4.5.3. Surgical Ablation

The electrophysiologist must be able to evaluate and manage patients who undergo surgical ablation for arrhythmias. Surgical ablation is currently most commonly performed for the treatment of AF, usually in the context of concomitant cardiac surgery (31). As the management options for patients with AF have expanded over the past decade, surgical ablation options for AF have also broadened to include stand-alone surgical procedures as well as hybrid approaches in which catheter ablation and EP testing are performed in the same setting or at a later date. Surgical ablation may also be utilized for the treatment of VT.

The trainee must know the pathophysiological basis of arrhythmia surgery. This includes an understanding of the surgical approaches that involve the creation of linear lesion sets in the left and right atria to achieve pulmonary vein isolation. A variety of energy sources may be utilized, and the trainee should have an understanding of the biophysics of the available energy sources. The trainee must also know the indications, techniques, and potential complications associated with surgical treatment of cardiac arrhythmias. The trainee must develop the skill to identify patients likely to benefit from surgical treatment of a cardiac arrhythmia and to follow patients after surgery. This includes an understanding of the comparative advantages and disadvantages of different lesion sets and energy sources, including the potential for collateral damage. The trainee should understand both the intraprocedural and standalone surgical options for the management of the left atrial appendage. The trainee must understand the potential for lesion gaps that place the patient at risk for atrial flutter, which may require subsequent catheter ablation.

4.6. Implantable Devices

The electrophysiologist implants a variety of CIEDs, which include ILRs, permanent pacemakers, subcutaneous ICDs, standard ICDs, and CRT devices (pacemaker or defibrillator). Specific requirements are outlined in the following text and include knowledge of the indications for each device and the skills to perform the implantation safely and manage any complications that may arise. The trainee must acquire the skills for preprocedural planning. This includes preprocedural assessment of hemodynamics, sedation risks, and anticoagulation management. Other preprocedural considerations include venous access and device pocket location (i.e., right versus left, prepectoral versus subpectoral). The trainee must also learn to recognize venous or cardiac anomalies (encompassing congenital and postsurgical abnormalities) that may affect procedural techniques, including lead positioning and the need for an epicardial pacing system. The trainee must acquire the procedural skills to implant single- or dual-chamber pacemakers safely, which includes the appropriate use of antibiotic therapy and other procedural measures to avoid infection, hemodynamic collapse, significant bleeding, pneumothorax, or cardiac perforation. The trainee must also be proficient in the safe use of anticoagulants, procedural sedation (48–51), techniques to minimize radiation exposure, and techniques to handle suboptimal venous access. Additionally, the trainee must learn to recognize potential complications quickly and be able to initiate appropriate therapy.

The trainee must also acquire all of the programming skills that relate to a particular CIED, including the ability to interrogate (encompassing remote interrogation), program, and troubleshoot devices and direct patient management. Knowledge of the bioengineering aspects of implantable devices and how these devices may be affected by environmental factors is also necessary. The trainee should also be able to manage the CIED patient who may be exposed to environmental electromagnetic interference. Management includes surgical procedures, radiation therapy, and referring the patient for magnetic resonance imaging. The trainee should also be familiar with global systems of device safety monitoring, the practitioner's role in supporting these safety systems, and protocols to manage patients with devices or leads that are on recall or advisory. The trainee must be able to review interrogations in both the clinic and remote monitoring settings, including having the ability to distinguish VAs from SVTs. Finally, trainees will learn how to manage patients with end-of-life considerations, including decisions about not replacing a device when appropriate.

4.6.1. Pacemakers

The trainee will acquire the knowledge and skills needed for permanent pacing. These include knowledge of the indications for implantation, such as the appropriate device type (single versus dual chamber versus CRT) and the skills to implant and manage patients with permanent pacemakers. The trainee must also attain proficiency in pacemaker programming both at the time of implant and at follow-up. These programming skills should include choice of pacing modes, understanding of timing intervals (including AV

delay, blanking, and refractory periods), management of rate response algorithms and sensors, mode switching algorithms, use of auto capture, and programming skills to maintain battery longevity and minimize ventricular pacing for non–CRT pacing systems. Programming skills should also include an understanding of the biophysics of pacing and of the technology of pacing leads and generators. The trainee will also become proficient in troubleshooting pacemaker performance and devising an appropriate management plan, including having the ability to diagnose and determine the root cause for problems such as loss of capture and inappropriate sensing, and to recognize the potential for a pacemaker malfunction or inappropriate lead position based on ECG. Troubleshooting also includes the ability to identify pseudo-malfunction due to vendor-specific pacing algorithms (e.g., algorithms that switch between AAI and DDD modes) and other problems such as distinguishing electromagnetic interference from lead fracture or malfunction.

4.6.2. Implantable Cardioverter-Defibrillators

Multiple large clinical trials have demonstrated that ICDs are effective in primary and secondary prevention of sudden death and reduction of total mortality in select populations (52). Trainees must thoroughly understand the results from clinical trials and registry data as well as how to incorporate professional guidelines with patient-specific factors (including comorbidities and anticipated psychosocial impact of ICDs) to select appropriate ICD candidates. Trainees should gain expertise in selecting the appropriate ICD device, including lead selection and evaluation for subcutaneous ICDs. Technical proficiency in device implantation is required and encompasses laboratory safety (including proper use of diagnostic radiation and electrosurgical instruments), surgical asepsis, sedation strategies, anticoagulation strategies, surgical site/pocket management, vascular entry (including situations with limited or anomalous venous access), lead implantation, lead evaluation (including sensing assessment, threshold testing, and anatomic location by fluoroscopy), and defibrillation testing (including understanding defibrillation waveforms and defibrillation probability curves). It is also important to understand the role of DFT testing, when not to perform DFT testing, and how to use alternate lead configurations and/or device programming to manage patients with a high DFT. The operator must understand ICD-related complications, including how to prevent, identify, and manage these complications both intraoperatively and long term. Knowledge is required of interrogating and programming ICDs from various manufacturers, both in-person and remotely, including reviewing diagnostic data; analyzing intracardiac electrograms; distinguishing SVTs from VAs; designing long-term follow-up programs; minimizing ventricular pacing if appropriate; performing noninvasive programmed stimulation; troubleshooting; and optimally programming ventricular tachyarrhythmia detection, discrimination, and termination algorithms (to minimize inappropriate shocks and favor antitachycardia pacing over shocks for VT termination) (53). The trainee must understand drug–device and environment–device (electromagnetic) interactions.

4.6.3. Resynchronization Therapy

Multiple large clinical trials have demonstrated that cardiac resynchronization improves quality of life, cardiac performance, and survival in select populations (52). Trainees must thoroughly understand the results from clinical trials and registry data as well as the recommendations from professional societies; this includes awareness of variables that potentially modify the anticipated response to CRT to reduce the probability of selecting nonresponders. The trainee should develop technical proficiency in CIED implantation, with specific additional skills for CRT, including detailed knowledge of cardiac venous anatomy and expertise in lead placement in the coronary sinus system. The operator must understand CRT-related complications, including how to prevent, identify, and manage these complications both intraoperatively and long term. When anatomy precludes transvenous left ventricular lead placement, the trainee should be familiar with alternative left ventricular lead placement, including the epicardial approach. Trainees should be skilled in managing patients with heart failure and understand how to evaluate, follow-up, and optimize device programming (including AV and interventricular timing) using ECG analysis, device-based algorithms, echocardiography, and/or alternative imaging modalities.

4.6.4. Implantable Loop Recorders

ILRs are increasingly used to detect sporadic arrhythmias. Trainees should thoroughly understand the indications for and considerations in recommending an ILR. The trainee should develop technical proficiency in implanting and explanting ILRs, including monitoring and managing potential complications. Knowledge is required of interrogating and programming ILRs in-person and remotely; this includes correct electrogram analysis and rhythm determination.

4.6.5. Left Atrial Appendage Occlusion/Ligation

Surgical and percutaneous left atrial appendage occlusion represents an emerging alternative strategy to systemic anticoagulation for reducing risk of thromboembolism and stroke in patients with AF (26,54). Trainees should be knowledgeable regarding the rationale, indications, technical approach, risks, and complications associated with different left atrial appendage occlusion/ligation strategies. They should be able to identify potential candidates for percutaneous or surgical left atrial appendage occlusion/ligation. Trainees should understand how to manage patients following left atrial appendage occlusion/ligation, including managing anticoagulant and/or antithrombotic therapy, and evaluating device efficacy long-term. For trainees seeking to perform appendage occlusion procedures, additional technical expertise is required (in some instances as part of a

multidisciplinary team), including proficiency in placing and possibly revising the occlusion device; recognizing and managing complications (including expertise in managing pericardial space complications); and interpreting advanced imaging modalities, including CT scanning, fluoroscopy, cine with contrast, and echocardiography.

4.6.6. Lead Management

Trainees should be knowledgeable about strategies to prevent lead- and device-related complications, including during CIED implantation, revision, and generator replacement. Heart rhythm specialists should understand the basic design of leads. Trainees should learn how to track the performance of a wide variety of leads from different manufacturers, monitor individuals with leads under advisory, and diagnose and manage lead failure. Trainees should thoroughly understand the indications for lead extraction and know how to manage patients undergoing extraction perioperatively including those with device infection and/or requiring subsequent CIED therapy (32). For trainees seeking to perform transvenous lead extraction, additional expertise is required in the technical aspects of the procedure, including exposure as the primary operator to various venous entry sites, extraction tools, and techniques under the direct supervision of an appropriately trained physician. The operator must understand potential complications of lead extraction, including how to prevent, identify, and manage these complications as part of a multidisciplinary extraction team.

5. Evaluation of Proficiency

Evaluation tools in EP include direct observation by instructors, case logbooks, conference and case presentations, multisource evaluations, trainee portfolios, and simulation. Self-assessment programs are available through the ACC and HRS (55,56). Training directors and trainees are encouraged to incorporate these resources in the course of training. Following completion of CCEP training, trainees will be eligible to take the ABIM Board Certification Examination in EP.

Judgement, case management, and bedside and procedural skills must be evaluated in every trainee. Quality of care and follow-up; reliability; judgment or decisions or actions that result in complications; interaction with other physicians, patients, and laboratory support staff; initiative; and the ability to make appropriate decisions independently should be considered. Trainees should maintain records of participation and advancement in the form of a Health Insurance Portability and Accountability Act–compliant electronic database or logbook that meets ACGME reporting standards and summarizes pertinent clinical information (number of cases, diagnoses, disease severity, outcomes, and disposition) for each encounter.

Under the guidance of the program director, faculty should record and verify each trainee's experiences, assess performance, and document satisfactory achievement. The program director is responsible for confirming experience and competence and reviewing the overall progress of individual trainees with the Clinical Competency Committee to ensure achievement of selected training milestones and identify areas in which additional focused training may be required.

6. Maintenance of Competency

As indicated in the competency table, there are a number of evaluation tools to ensure achievement of the knowledge, skills, and behaviors required for successful completion of CCEP fellowship. It is also important to ensure that learning is a lifelong process and that the core CCEP competencies are maintained over the course of a career. A number of mechanisms can aid in this regard; traditionally, this has included formal ABIM maintenance of EP certification. Individual practitioner outcomes, quality metrics, and peer review can also be important components of demonstration of competency.

For successful graduation from an accredited CCEP training program, a minimum number of various EP procedures has been suggested. Similarly, minimum annual numbers and a blend of procedures have been proposed for assurance of continued competence (13,20,57–61). It is important to recognize that there is a growing subspecialization career focus within EP, in which some highly skilled practitioners limit the scope of their clinical activity to pacemaker and defibrillator implantation and follow-up, whereas others focus their efforts on complex ablation, and still others do more straightforward ablations (not those that are complex) but have little continuing experience in implantable device work. Thus, although maintenance of some CCEP competencies is an expectation for all clinical cardiac electrophysiologists, the maintenance of other CCEP competencies—and the evaluation tools to assess them—can be career-focused.

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Appendix 1 Author Relationships With Industry and Other Entities (Relevant)—2015 ACC/AHA/HRS Advanced Training Statement on Clinical Cardiac Electrophysiology (A Revision of the ACC/AHA 2006 Update of the Clinical Competence Statement on Invasive Electrophysiology Studies, Catheter Ablation, and Cardioversion)

Committee Member	Employment	Consultant	Speakers Bureau	Ownership/ Partnership/ Principal	Personal Research	Institutional/ Organizational or Other Financial Benefit	Expert Witness
Douglas P. Zipes *(Chair)*	Indiana University—Distinguished Professor of Medicine, Pharmacology, and Toxicology; Director, Division of Cardiology	None	None	None	None	None	None
Hugh Calkins *(Vice Chair)*	Johns Hopkins Hospital—Professor of Medicine; Director of Electrophysiology	• AtriCure • Boehringer Ingelheim • Daiichi-Sankyo • Medtronic • St. Jude Medical*	None	None	None	• Boston Scientific* • St. Jude Medical*	None
James P. Daubert	Duke University Medical Center—Professor of Medicine; Director of Electrophysiology	• Biosense Webster* • Boston Scientific • Cardiofocus • Medtronic* • Orexigen	None	None	• Biosense Webster* • Boston Scientific* • Medtronic* • Vytronus (DSMB)	• Biotronik* • Boston Scientific* • Medtronic* • St. Jude Medical*	None
Kenneth A. Ellenbogen	VCU Medical Center—Director, Clinical Electrophysiology Laboratory	• AtriCure • Biosense Webster • Biotronik • Boston Scientific* • CardioNet • Daiichi-Sankyo • Janssen Pharmaceuticals • Medtronic* • Pfizer • Sanofi-aventis • St. Jude Medical	• Biotronik* • Boston Scientific* • Medtronic* • St. Jude Medical*	None	• Biosense Webster* • Boston Scientific* • Medtronic*	• Biosense Webster* • Boston Scientific* • Medtronic* • St. Jude Medical*	None
Michael E. Field	University of Wisconsin School of Medicine and Public Health—Assistant Professor of Medicine; Director of Cardiac Arrhythmia Service	None	None	None	None	None	None
John D. Fisher	Montefiore Medical Center—Director, Cardiac Arrhythmia Service	• Medtronic*	None	None	None	• Biotronik* • Boston Scientific* • Medtronic* • St. Jude Medical*	None
Richard Ira Fogel	The Care Group, LLC—Consulting Electrophysiologist	None	None	None	None	None	None

Appendix 1 (*continued*)

Committee Member	Employment	Consultant	Speakers Bureau	Ownership/ Partnership/ Principal	Personal Research	Institutional/ Organizational or Other Financial Benefit	Expert Witness
David S. Frankel	Hospital of the University of Pennsylvania—Assistant Professor of Medicine; Associate Director, Electrophysiology Fellowship Program	• Cardionet* • Medtronic • St. Jude Medical	None	None	None	• Medtronic • St. Jude Medical	None
Anurag Gupta	Cardiovascular Consultants Medical Group/Stanford Health Care—Cardiac Electrophysiologist	None	None	None	None	None	None
Julia H. Indik	University of Arizona, Sarver Heart Center—Professor of Medicine	None	None	None	None	None	None
Fred M. Kusumoto	Mayo Clinic Florida—Director, Heart Rhythm Services	None	None	None	None	None	None
Bruce D. Lindsay	Cleveland Clinic Foundation—Professor of Cardiology	• Biosense Webster • Boston Scientific • CardioInsight • Medtronic	None	None	None	• Boston Scientific* • Medtronic* • St. Jude Medical*	None
Joseph E. Marine	Johns Hopkins University School of Medicine—Associate Professor of Medicine; Associate Director of Electrophysiology	None	None	None	None	None	None
Laxmi S. Mehta	The Ohio State University Medical Center—Associate Professor of Medicine	None	None	None	None	None	None
Lisa A. Mendes	Vanderbilt Heart and Vascular Institute— Associate Professor of Medicine; Director, CV Medicine Fellowship Program	None	None	None	None	None	None
John M. Miller	Indiana University School of Medicine—Professor of Medicine; Director, Clinical Cardiac Electrophysiology	• Biosense Webster • Biotronik • Boston Scientific • Medtronic • St. Jude Medical • Topera Medical	None	None	None	• Biosense Webster* • Biotronik* • Boston Scientific* • Medtronic*	None
Thomas M. Munger	Mayo Clinic—Assistant Professor of Medicine	None	None	None	None	None	None
William H. Sauer	University of Colorado School of Medicine—Associate	• Biosense Webster • Boston Scientific	None	None	None	None	None

Appendix 1 (*continued*)

Committee Member	Employment	Consultant	Speakers Bureau	Ownership/ Partnership/ Principal	Personal Research	Institutional/ Organizational or Other Financial Benefit	Expert Witness
	Professor of Medicine; Director, Cardiac Electrophysiology	• Medtronic • St. Jude Medical					
Win-Kuang Shen	Mayo Clinic Arizona—Professor of Medicine; Chair, Division of Cardiovascular Diseases	None	None	None	None	None	None
William G. Stevenson	Brigham and Women's Hospital—Director, Clinical Cardiac Electrophysiology Program	• St. Jude Medical	None	None	None	• Biosense Webster†	None
Wilber W. Su	Banner-University Medical Center, Cavanagh Heart Center—Director, Electrophysiology	• Medtronic* • St. Jude Medical	None	None	None	None	None
Cynthia M. Tracy	George Washington University—Professor of Medicine; Associate Director Division of Cardiology, Director of Cardiac Services	None	None	None	None	None	None
Angela Tsiperfal	Stanford Health Care—Nurse Practitioner, Stanford Arrhythmia Service	• Medtronic	None	None	None	None	None

This table represents relationships of committee members with industry and other entities that were determined to be relevant to this document. These relationships were reviewed and updated in conjunction with all meetings and/or conference calls of the writing committee during the document development process. The table does not necessarily reflect relationships with industry at the time of publication. A person is deemed to have a significant interest in a business if the interest represents ownership of $\geq$5% of the voting stock or share of the business entity, or ownership of $\geq$$5,000 of the fair market value of the business entity; or if funds received by the person from the business entity exceed 5% of the person's gross income for the previous year. Relationships that exist with no financial benefit are also included for the purpose of transparency. Relationships in this table are modest unless otherwise noted. Please refer to http://www.acc.org/guidelines/about-guidelines-and-clinical-documents/relationships-with-industry-policy for definitions of disclosure categories or additional information about the ACC Disclosure Policy for Writing Committees.

According to the ACC and AHA, a person has a relevant relationship if: a) the relationship or interest relates to the same or similar subject matter, intellectual property or asset, topic, or issue addressed in the document; b) the company/entity (with whom the relationship exists) makes a drug, drug class, or device addressed in the document, or makes a competing drug or device addressed in the document; or c) the person or a member of the person's household has a reasonable potential for financial, professional or other personal gain or loss as a result of the issues/content addressed in the document.

ACC indicates American College of Cardiology; AHA, American Heart Association; DSMB, data safety monitoring board; and HRS, Heart Rhythm Society.

*Significant relationship.

†No financial benefit.

Appendix 2 Peer Reviewer Relationships With Industry and Other Entities (Relevant)—2015 ACC/AHA/HRS Advanced Training Statement on Clinical Cardiac Electrophysiology (A Revision of the ACC/AHA 2006 Update of the Clinical Competence Statement on Invasive Electrophysiology Studies, Catheter Ablation, and Cardioversion)

Name	Employment	Representation	Consultant	Speakers Bureau	Ownership/ Partnership/ Principal	Personal Research	Institutional/ Organizational or Other Financial Benefit	Expert Witness
Eric R. Bates	University of Michigan Hospitals and Health Centers—Professor of Medicine	Official Reviewer, ACC CMC Lead Reviewer	None	None	None	None	None	None
Luigi Di Biase	Albert Einstein, Montefiore—Director of Electrophysiology	Official Reviewer, AHA	• AtriCure • Biosense Webster* • Biotronik* • Boston Scientific • Hansen Medical • Medtronic • St. Jude Medical	None	None	None	• EpiEP	None
Anne Dubin	Lucile Packard Children's Hospital at Stanford University—Professor of Pediatrics; Director of Pediatric Electrophysiology	Official Reviewer, AHA	None	None	None	None	None	None
David E. Haines	Beaumont Health—Director, Heart Rhythm Center	Official Reviewer, HRS	None	None	• nContact	• ARCA Pharmaceutical† • Boston Scientific • CardioFocus • Medtronic • Toray*	None	None
Robert Helm	Boston University School of Medicine—Assistant Professor of Medicine	Official Reviewer, HRS	None	None	None	None	None	None
Richard Kovacs	Indiana University—QE and Sally Russell Professor of Cardiology	Official Reviewer, ACC BOT	• Asubio • Biomedical Systems	None	None	• Siemens†	• Cook Medical Institute	None
John L. Sapp	Queen Elizabeth II Health Sciences Centre—Professor of Medicine, Dalhousie University	Official Reviewer, HRS	• Biosense Webster* • Medtronic • St. Jude Medical	None	None	• Biosense Webster* • St. Jude Medical*	• Medtronic† • Pfizer • St. Jude Medical†	None
Usha Tedrow	Brigham and Women's Hospital Cardiovascular Division, Arrhythmia Unit, Harvard Medical School—Director, Clinical Cardiac Electrophysiology Program; Assistant Professor	Official Reviewer, AHA	• St. Jude Medical	None	None	None	• Biosense Webster • Medtronic • St. Jude Medical	None

Appendix 2 (*continued*)

Name	Employment	Representation	Consultant	Speakers Bureau	Ownership/ Partnership/ Principal	Personal Research	Institutional/ Organizational or Other Financial Benefit	Expert Witness
Jeffrey Williams	The Good Samaritan Hospital and Lebanon Cardiology Associates—Medical Director, Clinical Cardiac Electrophysiology	Official Reviewer, ACC BOG	None	None	None	None	None	None
James A. Arrighi	Rhode Island Hospital—Director, Nuclear Cardiology	Content Reviewer, ACC CMC	None	None	None	None	None	None
Javier E. Banchs	Baylor Scott & White Health—Director of Electrophysiology and Pacing	Content Reviewer, EP Training Program Director	• St. Jude Medical	None	None	None	• Biosense Webster* • Boston Scientific* • Daiichi-Sankyo • Medtronic* • Pfizer • St. Jude Medical*	None
Robert Campbell	Children's Healthcare of Atlanta Sibley Heart Center—Pediatric Cardiologist	Content Reviewer, ACC ACPC Council	None	None	None	None	None	None
George H. Crossley	Vanderbilt University—Associate Professor; Electrophysiology Fellowship Director	Content Reviewer, ACC EP Section Leadership Council	• Boston Scientific • Medtronic*	• Medtronic	None	None	• ARCA Biopharma • Boston Scientific • Medtronic • St. Jude Medical • Zio Patch	• Defendant, pneumothorax during pacemaker, 2015
Angelo Amato Vincenzo De Paola	Federal University of Sao Paulo, Escola Paulista de Medicina—Arrhythmias and Electrophysiology Director; Professor of Medicine	Content Reviewer, ACC AIG	None	None	None	None	None	None
Frederick Ehlert	New York Presbyterian, Columbia Campus—Electrophysiology Training Program Director	Content Reviewer, EP Training Program Director	None	None	None	None	None	None
Bulent Gorenek	Eskisehir Osmangazi University, Cardiology Department—Professor of Cardiology	Content Reviewer, ACC EP Section Leadership Council	None	None	None	None	None	None
Mariell Jessup	University of PennsylvaniaHeart and Vascular Center—Professor of Medicine	Content Reviewer, ABIM CV Board	None	None	None	None	None	None

Appendix 2 (*continued*)

Name	Employment	Representation	Consultant	Speakers Bureau	Ownership/ Partnership/ Principal	Personal Research	Institutional/ Organizational or Other Financial Benefit	Expert Witness
Jose A. Joglar	University of Texas, Southwestern—Electrophysiology Training Program Director	Content Reviewer, EP Training Program Director	None	None	None	None	None	None
John Kassotis	State University of New York, Downstate Medical Center—Electrophysiology Section Director; Electrophysiology Fellowship Program Director	Content Reviewer, EP Training Program Director	• Medtronic* • ZOLL Medical	• Boehringer Ingelheim* • Janssen Pharmaceuticals* • Pfizer*	None	None	None	None
Bradley P. Knight	Northwestern University—Professor of Medicine	Content Reviewer, EP Training Program Director	• Boston Scientific • Medtronic	• Biosense Webster • Biotronik • Boston Scientific • Medtronic	None	None	None	None
Kousik Krishnan	Rush University Medical Center—Electrophysiology Training Program Director	Content Reviewer, EP Training Program Director	• Janssen Pharmaceuticals • Pfizer	None	None	None	• Boston Scientific* • Medtronic* • St. Jude Medical*	None
Paul LeLorier	Louisiana State University Health Sciences Center, New Orleans—Associate Professor of Clinical Medicine and Neurology	Content Reviewer, EP Training Program Director	None	None	None	• Medtronic*	• Medtronic*	• Defendant, syncopal episode in workplace, 2015 • Plaintiff, complication of ablation and pacemaker placement, 2015 • Plaintiff, complication of ICD placement, 2015
Peem Lorvidhaya	Alpert Medical School, Brown University—Electrophysiology Training Program Director	Content Reviewer, EP Training Program Director	None	None	None	None	None	None

Appendix 2 (*continued*)

Name	Employment	Representation	Consultant	Speakers Bureau	Ownership/ Partnership/ Principal	Personal Research	Institutional/ Organizational or Other Financial Benefit	Expert Witness
Judith A. Mackall	University Hospitals Case Medical Center—Physician	Content Reviewer, EP Training Program Director	• St. Jude Medical	None	None	None	None	None
Pamela Mason	University of Virginia—CCEP Program Director	Content Reviewer, EP Training Program Director	• Biotronik • Boston Scientific • Janssen Pharmaceuticals • Medtronic	None	None	• Boston Scientific* • Medtronic*	• Boston Scientific	None
William M. Miles	University of Florida—Professor of Medicine	Content Reviewer, EP Training Program Director	None	None	None	• Medtronic • UCSF/ZOLL Medical	• Boston Scientific* • Medtronic* • St. Jude Medical*	None
Maged Nageh	Kaiser Permanente Los Angeles Medical Center—Attending Physician; Clinical Cardiac Electrophysiology Program Director	Content Reviewer, EP Training Program Director	None	None	None	None	None	None
Duy Thai Nguyen	University of Colorado—Electrophysiology Training Program Director	Content Reviewer, EP Training Program Director	None	None	None	None	None	None
Kristen K. Patton	University of Washington—Associate Professor of Medicine	Content Reviewer, ACC EP Section Leadership Council	None	None	None	None	None	None
Marwan Refaat	American University of Beirut Medical Center—Assistant Professor of Medicine	Content Reviewer, ACC EP Section Leadership Council	None	None	None	None	None	None
Lynda Rosenfeld	Yale University School of Medicine—Director, Yale University Clinical Cardiac Electrophysiology Fellowship Program	Content Reviewer, EP Training Program Director	None	None	None	• Medtronic†	• Boston Scientific* • Medtronic* • St. Jude Medical*	None
Peter Santucci	Loyola University—Electrophysiology Training Program Director; Professor of Medicine	Content Reviewer, EP Training Program Director	None	None	None	None	• Biosense Webster* • Biotronik* • Boston Scientific* • Medtronic*	None
Komandoor Srivathsan	Mayo Clinic—Associate Professor, College of Medicine	Content Reviewer, EP Training Program Director	• St. Jude Medical	• Biosense Webster	None	None	None	None

Appendix 2 (*continued*)

Name	Employment	Representation	Consultant	Speakers Bureau	Ownership/ Partnership/ Principal	Personal Research	Institutional/ Organizational or Other Financial Benefit	Expert Witness
Gregory Supple	University of Pennsylvania Health System—Associate Director, Cardiac Electrophysiology Fellowship Program; Assistant Professor of Clinical Medicine	Content Reviewer, EP Training Program Director	• Biotronik • St. Jude Medical	None	None	• Boston Scientific • Medtronic	None	None
Gaurav A. Upadhyay	University of Chicago—Assistant Professor of Medicine	Content Reviewer, ACC EP Section Leadership Council	• Biosense Webster • Biotronik • Boston Scientific • Medtronic	None	None	None	None	None

This table reflects peer reviewers' relationships with industry and other entities that were reported and deemed to be relevant to this document, as well as employment, representation in the review process, and reporting categories. Names are listed in alphabetical order within each category of review. The table does not necessarily reflect relationships with industry at the time of publication. A person is deemed to have a significant interest in a business if the interest represents ownership of $\geq$5% of the voting stock or share of the business entity, or ownership of $\geq$$5,000 of the fair market value of the business entity; or if funds received by the person from the business entity exceed 5% of the person's gross income for the previous year. Relationships in this table are modest unless otherwise noted. Please refer to http://www.acc.org/guidelines/about-guidelines-and-clinical-documents/relationships-with-industry-policy for definitions of disclosure categories, relevance, or additional information about the ACC Disclosure Policy for Writing Committees.

ABIM indicates American Board of Internal Medicine; ACPC, Adult Congenital and Pediatric Cardiology; AIG, Assembly of International Governors; BOG, Board of Governors; BOT, Board of Trustees; CMC, Competency Management Committee; CV, Cardiovascular; EP, Electrophysiology; UCSF, University of California, San Francisco; other abbreviations as in Appendix 1.

*Significant relationship.

†No financial benefit.

Appendix 3. Abbreviation List

ABIM = American Board of Internal Medicine
ACC = American College of Cardiology
ACGME = Accreditation Council for Graduate Medical Education
AF = atrial fibrillation
AHA = American Heart Association
AP = accessory pathway
AV = atrioventricular
CCEP = clinical cardiac electrophysiology
CIED = cardiac implantable electronic devices
CMR = cardiovascular magnetic resonance
COCATS = Core Cardiovascular Training Statement
CRT = cardiac resynchronization therapy
CT = computed tomography
DFT = defibrillation threshold
ECG = electrocardiogram
EP = electrophysiology
HRS = Heart Rhythm Society
ICD = implantable cardioverter-defibrillator
ILR = implantable loop recorder
RWI = relationships with industry
SVT = supraventricular tachycardia
VA = ventricular arrhythmia
VT = ventricular tachycardia