Title
COCATS 4 Task Force 7: Training in Cardiovascular Computed Tomographic Imaging

Journal
Journal of Nuclear Cardiology, 22(4)

ISSN
1071-3581

Authors
Garcia, Mario J
Blankstein, Ron
Budoff, Matthew J
et al.

Publication Date
2015-08-01

DOI
10.1007/s12350-015-0163-y

Peer reviewed

COCATS 4 Task Force 7: Training in Cardiovascular Computed Tomographic Imaging

Endorsed by the American Society of Nuclear Cardiology, Society of Atherosclerosis Imaging and Prevention, Society for Cardiovascular Angiography and Interventions, and Society of Cardiovascular Computed Tomography (pending review of final report)

Mario J. Garcia, MD, FACC, FACP *Chair*; Ron Blankstein, MD, FACC; Matthew J. Budoff, MD, FACC, FSCAI (*Society of Cardiovascular Computed Tomography Representative*); John M. Dent, MD, FACC; Douglas E. Drachman, MD, FACC; John R. Lesser, MD, FACC; Maleah Grover-McKay, MD, FACC; Jeffrey M. Schussler, MD, FACC, FSCAI (*Society for Cardiovascular Angiography and Interventions Representative*); Szilard Voros, MD, FACC (*Society of Atherosclerosis Imaging and Prevention Representative*); L. Samuel Wann, MD, MACC (*American Society of Nuclear Cardiology Representative*)

1. Introduction

1.1. Document Development Process

1.1.1. Writing Committee Organization

The Writing Committee was selected to represent the American College of Cardiology (ACC), American Society of Nuclear Cardiology (ASNC), Society for Cardiovascular Angiography and Interventions (SCAI), Society of Atherosclerosis Imaging and Prevention (SAIP), and Society of Cardiovascular Computed Tomography (SCCT), and included a cardiovascular training program director, a cardiovascular computed tomography (CCT) training program director, advanced multimodality cardiovascular imaging training program director, a cardiologist early in his career, as well as highly experienced specialists practicing in both academic and community-based settings, and physicians experienced in defining and applying training standards according to the 6 general competency domains promulgated by the Accreditation Council for Graduate Medical Education (ACGME) and American Board of Medical Specialties (ABMS), and endorsed by the American Board of Internal Medicine (ABIM). The ACC determined that relationships with industry or other entities were not relevant to the creation of this general cardiovascular training statement. Employment and affiliation information for authors and peer reviewers are provided in Appendices 1 and 2, respectively, along with disclosure reporting categories. Comprehensive disclosure information for all authors, including relationships with industry and other entities, is available as an online supplement to this document.

1.1.2. Document Development and Approval

The writing committee developed the document, approved it for review by individuals selected by the ACC, ASNC, SAIP, SCAI, and SCCT, and addressed their comments. The document was revised

and posted for public comment from December 20, 2015 to January 6, 2015. Authors addressed additional comments to complete the document. The final document was approved by the Task Force, COCATS Steering Committee, ACC Competency Management Committee and ratified by the ACC Board of Trustees in February 2015 and endorsed by ASNC, SAIP, SCAI, and SCCT. This document is considered current until the ACC Competency Management Committee revises or withdraws it.

1.2. Background and Scope

CCT is a rapidly evolving technique for assessing cardiovascular anatomy. The anatomical detail, complex imaging devices and protocols and evolving clinical applications of this modality require that all cardiovascular trainees receive training in CCT imaging during fellowship. Clinical application of CCT encompasses noncontrast (coronary calcium evaluation), contrast (CCT angiography and function), and hybrid studies (combining nuclear cardiology techniques with CCT). Computed tomography, like catheterization, provides anatomical and functional information (e.g., coronary anatomy and left ventricular ejection fraction, respectively). Hybrid devices incorporate high-speed multidetector computed tomography (MDCT) technology, positron emission tomography (PET), and single-photon emission computed tomography (SPECT) detector systems. Current hybrid systems (MDCT plus nuclear) provide attenuation correction for SPECT and PET, further improving the diagnostic accuracy of traditional radionuclide techniques.

This training statement has been designed for fellows-in-training and is not intended for physicians already in practice (1). Fellows-in-training are expected to gain exposure to CCT during fellowship years and incorporate this experience with knowledge of echocardiography, nuclear cardiology, cardiovascular magnetic resonance (CMR), and cardiac catheterization, as appropriate. All fellows should be exposed to the fundamental aspects of CCT; but, only those who achieve levels of experience beyond Level I will be sufficiently qualified to interpret CCT scans independently. At the conclusion of training, all fellows should be familiar with CCT assessment of cardiovascular anatomy, physiology, and pathophysiology and know the clinical application of CCT, principles of CCT physics, and radiation generation and exposure. Since many CCT studies require the administration of intravenous iodinated contrast, fellows should be familiar with the protocols for contrast administration and subsequent contrast kinetics, as well as the potential adverse events from contrast exposure and appropriate treatment. In particular, fellows should be able to define the methods for contrast-enhanced CCT imaging of the pericardium, right and left heart chambers, and the great vessels. Given the potential hazards of exposure to medical radiation, trainees should become familiar with appropriate patient

selection, dose reduction techniques, and the principle of maintaining radiation exposure at the lowest level reasonably achievable.

Every cardiovascular fellow should develop familiarity with the technical performance, interpretation, strengths, and limitations of CCT and its multiple clinical applications. In addition, every cardiovascular fellow should gain an understanding of how to effectively use the information provided by cardiac CT, together with other clinical and imaging tests (when available), in making patient management decisions. It is recognized that CCT is an evolving technology in a rapid phase of development and improvement, with an expanding list of clinical indications.

The Task Force was charged with updating previously published standards for training fellows in clinical cardiology enrolled in ACGME-certified fellowship (2) based on: 1) changes in the field since 2008 and as part of a broader effort to establish consistent training criteria across all aspects of cardiology, and 2) the evolving framework of competency-based medical education described by the ACGME Outcomes Project and the 6 general competencies endorsed by ACGME and ABMS. The background and overarching principles governing fellowship training are provided in the Introduction to COCATS, and readers should become familiar with this foundation before considering the details of training in a subdiscipline like CCT. The Steering Committee and Task Forces recognize that implementation of these changes in training requirements will occur incrementally over time.

For most areas of cardiovascular imaging, 3 levels of training are delineated:

Level I training defines the fundamental level of experience required of all fellows-in-training in order to be considered competent to practice cardiology independently. Level I training should be accomplished during every standard 3-year training program in cardiology. This entails understanding the basic principles, indications, applications, and technical limitations of CCT, as well as the interrelation of CCT with other diagnostic methods. Level I certification does not qualify a trainee to perform or interpret CCT studies independently.

Level II training refers to the additional training in 1 or more areas that enables a cardiologist to perform or interpret specific procedures or render more specialized care for patients and conditions. This level of training is recognized for those areas in which an accepted instrument or benchmark, such as a qualifying examination, is available to measure specific knowledge, skills, or competence. Level II training in selected areas may be achieved by some trainees during the standard 3-year cardiovascular fellowship, based on the trainees' career goals and use of elective rotations. It is anticipated that during a

standard 3-year cardiovascular fellowship training program, sufficient time will be available to receive Level II training in a specific subspecialty. In the case of CCT, Level II is defined as the minimum level of experience required to perform and interpret CCT independently.

Level III training in CCT, like other noninvasive imaging modalities, should include the principles of multimodality imaging (see COCATS Task Force 4: Multimodality Imaging). This requires additional training and experience beyond the cardiovascular fellowship to acquire specialized knowledge and experience in performing, interpreting, and training others to perform specific procedures or render advanced specialized care at a high level of skill. In the case of CCT, Level III expertise would enable the trainee to direct a CCT laboratory, train others in CCT and conduct advanced imaging research. Level III training is described here only in broad terms to provide context for trainees. The additional exposure and requirements for Level III training will be addressed in a subsequent, separately published in Advanced Training Statement.

The number of cases, procedures, and experiences recommended is based on published guidelines, competency statements, and the opinions of the members of the writing group. It is assumed that training is directed by appropriately-trained mentors in an ACGME-accredited program and that satisfactory completion of training is documented by the program director. The number and types of encounters and the duration of training typically required are summarized in Section 4.

2. General Standards

Three organizations—the ACC, AHA, and SCCT—have addressed training requirements and guidelines for patient selection (1, 3); clinical indications (4, 5); study performance, interpretation and reporting (6, 7); and educational objectives (2) for fellowship training in CCT. The recommendations are congruent and address faculty, facility requirements, emerging technologies, and practice. Cardiovascular fellowship programs should satisfy the requirements regarding facilities and faculty for training in CCT. Candidates for the ABIM examination for certification in cardiovascular diseases should review the specific ABIM requirements, and those seeking advanced certification in CCT should review the specific requirements of the Certification Board of Cardiovascular Computed Tomography (CBCCT) (8).

Eligibility for U.S.-trained cardiovascular fellows to sit for the CBCCT examination requires that training take place in a program accredited by the ACGME (8). The intensity and depth of training and required resources may vary according to the level of training provided.

2.1. Faculty

Faculty should include cardiovascular imaging specialists knowledgeable about the risks to the patient and medical personnel associated with radiation exposure and skilled in the performance and interpretation of CCT studies. The program must have a minimum of 2 key clinical CCT faculty members, including the program director, who are board-certified in CCT or possess equivalent qualifications. A physician is considered to have equivalent qualifications if he or she trained in a similar environment for a similar duration of time, supervised the required number of studies, and performed supervised and independent interpretations. Faculty must participate with trainees in imaging acquisition, processing, and interpretation.

2.2. Facilities

Facilities must be adequate to ensure a safe and effective environment for conducting diagnostic CCT studies and provide didactic instruction to fellows-in-training. Appropriate infrastructure, personnel, and equipment should be available to enable image processing, interpretation, and didactic interactions between faculty and trainee.

The CCT laboratory in which training is undertaken should be under the direct supervision of a full-time qualified director (or directors) with Level III training or equivalent. The training guidelines set forth in this document pertain primarily to trainees performing CCT examinations in adult patients with acquired or congenital heart disease.

2.3. Equipment

CCT laboratories require specialized equipment for the safe performance and interpretation of diagnostic studies. This equipment includes a multislice CCT scanner with a minimum of 64-slice and ECG-gating capabilities; specialized equipment for contrast administration and patient monitoring; and computer network infrastructure for data storage, transmission, processing, study interpretation, and reporting (8).

2.4. Ancillary Support

Ancillary support should be available to obtain intravenous access, administer intravenous medications, monitor patients after procedures, and treat potential complications including performance of emergency cardiopulmonary resuscitation.

3. Training Components

3.1. Didactic Program

The educational curriculum in CCT should include didactic lectures, reference reading material, case discussions, and formal case presentations. The curriculum should supplement the hands-on and clinical case interpretation experiences to ensure that the medical knowledge milestones detailed in Section 4.1 are met. Consequently, knowledge pertaining to CCT should be acquired in the following areas: epidemiology, CCT physics, image processing, pathophysiology, and management of coronary artery disease. In addition, didactic sessions should include discussions of the diagnostic accuracy of CCT, including sensitivity and specificity, when compared to the reference standard of invasive angiography or myocardial perfusion imaging, as well as knowledge of the advantages and disadvantages of CCT compared with other cardiovascular imaging modalities. Didactic teaching should address appropriate utilization of CCT and integration of the CCT results with other data to enhance patient management.

Each fellow should receive documented training from a CCT mentor and/or physicist on the basic physics of CT in general and CCT in particular. Lectures should include training in principles of radiation protection, hazards of radiation exposure to both patients and personnel, and techniques for reporting and measuring radiation doses. The CCT mentor should also discuss cardiac and great-vessel anatomy, contrast administration and kinetics, principles of 3-dimensional imaging and post-processing, and appropriate post-procedural patient monitoring.

3.2. Clinical Experience

Interpretation of a designated minimum number of CCT studies will typically be required to approach Level I competency (See Section 4.2). In addition, for a certain number of cases, the trainee should be present and participate in acquisition of the images. For these cases, the following 3 conditions must be met:

1. The trainee must be present in the scanning control room.
2. For Level I or II training, the fellow must participate interactively in manipulation of the processed images for evaluation of the study. Interpretation of each case should include all components of cardiac structure and function (when available), as well as noncardiac structures.
3. During this image evaluation process, there must be an opportunity for interaction between the trainee and trainer.

The CCT program should expose trainees to a wide array of CCT indications and imaging protocols and a varied patient population, including patients with complex congenital heart disease. It is important to emphasize that merely completing a certain number of studies does not equate to competency, which instead must be assessed individually by supervising faculty.

3.3. Hands-On Experience

Hands-on training is important, not only to develop technical expertise regarding image acquisition and interpretation, but also as a valuable aid to learning tomographic and 3-dimensional cardiac anatomy. Through acquisition and interpretation of data, trainees should learn to recognize appropriate image quality and understand the source of—and recognize techniques for—avoiding artifacts (e.g., breath-holding, gating, arrhythmias).

4. Summary of Training Requirements

4.1. Development and Evaluation of Core Competencies

Training and requirements for CCT address the 6 general competencies promulgated by the ACGME/ABMS and endorsed by the ABIM. These competency domains include: 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 core 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/ABIM reporting milestones. The ACC has adopted this format for its competency and training statements, career milestones, lifelong learning, and educational programs. Additionally, it has developed tools to assist physicians in assessing, enhancing, and documenting these competencies.

Table 1 delineates each of the 6 competency domains, as well as their associated curricular milestones for training in CCT. The milestones are categorized into Level I and Level II (as previously defined in this document) and indicate the stage of fellowship training (12, 24 or 36 months, and additional time points) by which the typical cardiovascular trainee should achieve the designated level. Recognizing that programs may vary with respect to the sequence of clinical experiences provided to trainees, the milestones at which various competencies are reached may vary as well. Level I competencies may be achieved at earlier or later time points. Acquisition of Level II skills requires

additional training and Level III skills requires training in a dedicated CCT program. The table also describes examples of evaluation tools suitable for assessment of competence in each domain.

Table 1. Core Competency Components and Curricular Milestones for Training in Cardiovascular Computed Tomography

Medical Knowledge	Milestones (Months)			
	12	24	36	Add
1. Know the principles of cardiovascular computed tomographic scanning and the scanning modes.		I		
2. Know the risks and safety measures for cardiovascular computed tomographic scanning, including radiation reduction strategies.			I	
3. Know the appropriate indications for cardiovascular computed tomography for screening or evaluating symptoms in patients with suspected cardiac disease.		I		
4. Know the indications, potential adverse effects, prevention, and treatment of complications of iodinated contrast agent use in cardiovascular computed tomographic studies.		I		
5. Know the indications and protocols for beta-adrenergic blocking drugs and nitroglycerin during cardiovascular computed tomographic studies.			II	
6. Know the principles of cardiovascular computed tomographic scan collimation, temporal resolution, table speed, field of view, and window and level view settings.			II	
7. Know the principles of post-processing methods for cardiovascular computed tomographic scanning.			II	
8. Know the algorithms used for reconstruction, and recognize and isolate causes of artifacts.			II	
9. Know the principles of quantitative coronary artery calcium scoring.			II	
10. Know normal chest anatomy and common incidental extra cardiac findings.			II	
11. Know the characteristic cardiovascular computed tomographic images of normal cardiac chambers and great vessels, normal coronary arteries and veins, and normal variants.			I	
12. Know the characteristic cardiovascular computed tomographic findings of coronary atherosclerosis including plaque morphology and assessment of stenosis severity.			II	
13. Know the characteristic cardiovascular computed tomographic findings of anomalous coronary arteries and other common congenital anomalies.			II	
14. Know the characteristic cardiovascular computed tomographic findings in postoperative cardiac surgical patients including internal mammary artery and saphenous vein bypass grafts.			II	
15. Know the characteristic cardiovascular computed tomographic findings of acquired and congenital valvular disease.			II	
16. Know the characteristic cardiovascular computed tomographic findings of left atrial and pulmonary and coronary venous abnormalities.			II	
17. Know the characteristic cardiovascular computed tomographic findings of pericardial disease.			II	

18. Know the characteristic cardiovascular computed tomographic findings of cardiomyopathies and infiltrative myocardial diseases.			II	
19. Know the differential diagnosis of cardiac masses identified by cardiovascular computed tomography.			II	
20. Know the characteristic cardiovascular computed tomographic findings of common diseases of the aorta and great vessels.			II	
21. Know the characteristic cardiovascular computed tomographic findings of pulmonary embolism and primary and acquired pulmonary vascular diseases.			II	
22. Know when to request help with interpretation of difficult studies, such as patients with complex congenital heart disease.			I	
***Evaluation Tools*:** conference presentation, direct observation, in-training exam				
Patient Care and Procedural Skills	**12**	**24**	**36**	**Add**
1. Skill to appropriately utilize cardiovascular computed tomography in the evaluation and management of patients with known or suspected cardiovascular disease.			I	
2. Skill to integrate cardiovascular computed tomographic findings with other clinical information in patient evaluation and management.			I	
3. Skill to recognize and treat contrast-related adverse reactions.	I			
4. Skill to independently perform and interpret cardiovascular computed tomography.			II	
5. Skill to perform and interpret hybrid CT/SPECT and CT/PET imaging.				III
***Evaluation Tools*:** conference presentation, direct observation, logbook				
Systems-Based Practice	**12**	**24**	**36**	**Add**
1. Incorporate appropriate use criteria, risk/benefit, and cost considerations in the use of cardiovascular computed tomography and alternative imaging modalities.		I		
***Evaluation Tools*:** conference presentation, direct observation, multisource evaluation				
Practice-Based Learning and Improvement	**12**	**24**	**36**	**Add**
1. Identify knowledge and performance gaps and engage in opportunities to achieve focused education and performance improvement.			I	
2. Utilize point-of-care educational resources (e.g., guidelines, appropriate use criteria, and clinical trial results).			I	
***Evaluation Tools*:** conference presentation, direct observation, reflection and self-assessment				
Professionalism	**12**	**24**	**36**	**Add**

1. Work effectively in an interdisciplinary CCT environment.		I		
2. Reliably obtain patient informed consent, ensuring that patients understand the risks and benefits of, and alternatives to, cardiovascular computed tomographic testing.		I		
3. Know and promote adherence to clinical practice guidelines.		I		
Evaluation Tools: conference presentation, direct observation, multisource evaluation				
Interpersonal and Communication Skills	**12**	**24**	**36**	**Add**
1. Communicate testing results to physicians and patients in an effective and timely manner.		I		
Evaluation Tools**:** direct observation, multisource evaluation				

4.2. Number of Procedures and Duration of Training

The specific competencies for Levels I and II are delineated in Table 1. The minimum volume of procedures typically required to achieve competence at each level of training in CCT is summarized in Table 2.

Table 2. Requirements for CCT Study Performance and Interpretation to Achieve Level I and Level II Clinical Competence

	Minimum Number of Mentored Examinations Present During Performance	Minimum Number of Mentored Examinations Interpreted
Level I	15	50
Level II	65	250 CCT cases†

†Cumulative numbers; caseload recommendations may include studies from an established teaching file, previous CCT cases, journals and/or textbook, or electronic/on-line courses/continuing medical education.

Although approximate numbers of procedures are listed, it is more important to assess achievement by evaluation of outcome measures. Requirements for Level II training may be satisfied, for example, by supervised time, courses, case studies, CD/DVD training, participation in major medical meetings devoted to CCT, or other relevant educational training activities. The caseload recommendations may include studies from an established teaching file, previous CCT cases, and electronic/online learning tools or courses.

4.2.1. Level I Training Requirements

Level I training is the minimal introductory experience necessary to gain familiarity with CCT but does not provide sufficient competence for independent interpretation of CCT images. The trainee should obtain intensive exposure to the methodology and multiple applications of CCT for approximately 1 month, which may occur in conjunction with other training activities. During this cumulative experience, individuals should be actively involved in CCT interpretation under the direction of a qualified (at minimum Level II, but preferably Level III–trained) physician-mentor (1). There should be a mentored interpretative experience of at least 50 studies for which other correlative cardiovascular imaging data are also available. Mentored interpretive experience may include studies from an established teaching file of CCT cases, CD/DVD, and on-line training.

For all levels of competence, the trainee should attend lectures on the basic concepts of CCT and in parallel utilize self-study reading material. A basic understanding of CCT includes the physics of CCT imaging, basics of CCT scan acquisition, safety issues, recognition and management of side effects of medications administered in the course of CCT, including beta-blockers and nitrates in addition to iodinated contrast, post-processing methods, and basics of CCT interpretation compared with other cardiovascular imaging modalities including echocardiography, nuclear cardiology, CMR, and invasive cardiovascular x-ray angiography. Ancillary cardiac diagnostic studies should evaluate ventricular hypertrophy, dilation, valvular pathology such as mitral stenosis/annular and leaflet calcification, cardiac masses, aortic valve pathology (number of cusps, calcification and stenosis), pericardial and infiltrative myocardial diseases, internal mammary arteries, left atrial, pulmonary and coronary venous abnormalities, thoracic aortic pathology, and saphenous vein grafts.

4.2.2. Level II Training Requirements

Level II training is defined as the minimum experience necessary for a physician to independently perform and interpret CCT. To accomplish this, the fellow should devote an additional 1 month or equivalent and interpret a minimum of 200 additional contrast studies. Non-contrast and contrast-enhanced studies may be evaluated in the same patients. Of these, at least 65 should be performed with the fellow present under appropriate supervision. Competence at this level implies that the fellow is sufficiently experienced to help acquire, if necessary, and interpret the CCT examination accurately and independently. Continued exposure to special CCT procedures, such as hybrid studies with nuclear imaging and integration of images into electrophysiologic procedures, is appropriate during Level II training.

To qualify for Level II certification, the trainee should be exposed to an additional 200 cases, demonstrate competency for independent performance and interpretation, and meet the following components:

1. The trainee must be present in the scanning suite control room and actively participate in the acquisition of 50 cases.
2. A trainee may view a maximum of 50 cases from an educational CD or presentation granting continuing medical education credit that contains CCT data review, clinical information, and appropriate clinical correlative information (e.g., invasive coronary angiographic images).
3. At least 150 cases must involve interactive manipulation of reconstructed data sets using a 3-dimensional imaging workstation.
4. At least 20 cases must include evaluation of cardiac function.
5. At least 20 cases should involve evaluation of structural and/or congenital heart disease.
6. At least 15 cases must involve evaluation of bypass graft vessels.
7. At least 40 cases should be correlated with invasive angiography and/or myocardial perfusion imaging.
8. In at least 50 cases the trainee should be actively involved and demonstrate competency in acquisition, interpretation, and reporting of CCT images.

A fellow with Level II training should demonstrate clear understanding of the various types of CCT scanners available for cardiovascular imaging and understand, at a minimum, common issues related to imaging, post-processing, and scan interpretation.

4.2.2.1. Incidental Noncardiac Findings

During a CCT examination, the standard use of a small field of view (e.g., limited lung fields) precludes complete evaluation of the entire thorax. To address the possibility that significant noncardiac imaging findings, (e.g., aortic disease, hilar adenopathy, large pulmonary nodules, and pulmonary emboli) might be present on a CCT scan, specific interpretation of the extracardiac fields should be performed as discussed below. The patient, referring physician, and trainee should understand that the focus of the CCT

examination is detection of cardiac disease, and the scan does not encompass the entire lung field. Fellows should be trained to recognize incidental findings in the interest of providing high-quality care. Cases in which these extracardiac findings are identified require referral to a specialist with expertise in chest imaging. To this end, Level II and Level III training should encompass review of all cardiovascular cases for noncardiac findings. The review of 150 CCT cases for incidental findings should include studying a dedicated teaching file of CCT cases featuring significant extracardiac pathology, and the core curricula for Level II and Level III should include specific didactic training in the extracardiac pathology often encountered during diagnostic CCT.

4.2.3. Level III Training Requirements

Level III training enables a physician to direct an academic CCT section, independent CCT facility, or clinic. This individual would be responsible for quality control and training of technologists and mentoring other physicians in training. In addition to the requirements for Level I and Level II training, Level III training requires additional training beyond the standard 3-year cardiovascular fellowship devoted to CCT and additional training in 1 or more other imaging modalities. Level III trainees should be involved in the acquisition and interpretation of CCT imaging examinations and demonstrate the ability to over-read CCT studies independently. Level III training should include participation in research, teaching, and the administrative aspects of laboratory operations, including data management, report generation and distribution, quality improvement, accreditation, and understanding of evolving multimodality imaging technologies. Level III training in any noninvasive modality requires training in more than 1 noninvasive imaging modality.

4.2.4. Training in Multiple Imaging Modalities

The recent emergence of noninvasive imaging modalities, especially cardiovascular magnetic resonance and computed tomography angiography, is having a profound impact on the practice of cardiology and the fellowship training experience. The cardiovascular medicine specialist is increasingly expected to provide expertise in 2 or more of the imaging techniques. It is understandable, then, that trainees will desire the opportunity to gain exposure to multiple imaging modalities during their fellowship experience. To the degree possible, the training program should strive to meet these needs by offering a “multimodality” imaging experience (see COCATS Task Force 4: Multimodality Imaging). This might include an appreciation for each technique’s uses and clinical indications, strengths and limitations, safety issues, and the guidelines and appropriateness criteria, when available.

4.2.5. Vascular CT Imaging

Vascular CT represents an optional portion of training. As a cardiovascular specialist, the cardiovascular fellow should acquire skills beyond those pertaining to cardiac structure and the coronary vasculature. Among the advantages of newer multidetector CT equipment is very rapid imaging of the carotid, renal, or peripheral vessels with small contrast requirements and high spatial resolution. The physics, acquisition parameters, and reconstruction techniques are similar, but vascular imaging requires additional knowledge of the anatomy and pathophysiology specific to each vascular territory. Level I, II, or III CCT training does not imply that trainees have acquired the vascular imaging expertise associated with the corresponding levels of CCT training.

5. Evaluation of Competency

Evaluation tools in CCT include direct observation by instructors, in-training examinations, case logbooks, conference and case presentations, multisource evaluations, trainee portfolios, simulation, and reflection and self-assessment. Acquisition and interpretive skills should be evaluated in every trainee. Interaction with other physicians, patients, and laboratory support staff; initiative; reliability; decisions or actions that result in clinical error; and the ability to make appropriate decisions independently and appropriate follow-up should be considered in these assessments. Trainees should maintain records of participation and advancement in the form of a HIPAA-compliant electronic database or logbook that meets ACGME reporting standards and summarizes pertinent clinical information (e.g., number of cases, diversity of referral sources, testing modalities, diagnoses and findings). The use of CMR should be aligned with both clinical need and appropriateness criteria. Trainees should be prepared to explain why a given CCT test is better suited to the clinical question than another imaging option. Fellows should document clinical correlation with the other imaging, hemodynamic, invasive laboratory, surgical pathology, and outcomes data to enhance understanding of the diagnostic utility and value of various studies. Finally, experiences in CCT should be assessed against measures of quality with regard to test selection, performance, interpretation, and reporting in the interest of appreciating the potential adverse consequences of suboptimal testing (2).

The ACC, AHA, and SCCT have formulated a clinical competence statement on the performance, interpretation and reporting of CCT studies (5). Self-assessment programs and competence examinations in CCT are available through the ACCF and other organizations. Program directors and trainees are encouraged to incorporate these resources in the course of training. We strongly encourage the use of

examinations (e.g., the Cardiac Computed Tomography Self-Assessment Program [CCTSAP]) at the end of CCT training.

Under the aegis of the program director and director of each imaging laboratory, facility, or program, the 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 assure achievement of selected training milestones and identify areas in which additional focused training may be required.

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

APPENDIX 1. AUTHOR RELATIONSHIPS WITH INDUSTRY AND OTHERS ENTITIES (RELEVANT)—COCATS 4 TASK FORCE 7: TRAINING IN CARDIOVASCULAR COMPUTED TOMOGRAPHY

Committee Member	Employment	Consultant	Speakers Bureau	Ownership/ Partnership / Principal	Personal Research	Institutional, Organizational, or Other Financial Benefit	Expert Witness
Mario J. Garcia *(Chair)*	Montefiore Medical Center, Albert Einstein College of Medicine—Chief of Cardiology; Professor of Medicine and Radiology	None	None	None	None	None	None
Ron Blankstein	Brigham and Women's Hospital—Co-Director, Noninvasive Cardiovascular Imaging Training Program, Cardiovascular Division & Department of Radiology; Harvard Medical School—Assistant Professor in Medicine and Radiology	None	None	None	None	None	None
Matthew J. Budoff	Los Angeles Biomedical Research Institute —Program Director, Division of Cardiology	None	None	None	None	None	None
John M. Dent	University of Virginia Health System Department of Medicine—Professor of Medicine (Cardiology)	None	None	None	None	None	None
Douglas E. Drachman	Massachusetts General Hospital—Training Director, Division of Cardiology	None	None	None	None	None	None
John R. Lesser	Minneapolis Heart Institute— Director of Cardiovascular CT and MRI	None	None	None	None	None	None
Maleah Grover-McKay	DaVita Healthcare Partners—Director, Plaza Cardiology	None	None	None	None	None	None

Committee Member	Employment	Consultant	Speakers Bureau	Ownership/ Partnership / Principal	Personal Research	Institutional, Organizational, or Other Financial Benefit	Expert Witness
Jeffrey M. Schussler	Baylor University Medical Center—Medical Director, Cardiovascular ICU; Texas A&M College of Medicine—Professor of Medicine	None	None	None	None	None	None
Szilard Voros	Stony Brook University Medical Center, State University of New York—Visiting Professor of Radiology and Medicine/Cardiology; Global Genomics Group—Founder; Chief Executive Officer; Health Diagnostic Laboratory—Executive Vice President; Chief Clinical Strategy Officer	None	None	None	None	None	None
L. Samuel Wann	University of Wisconsin, Madison and Medical College of Wisconsin, Milwaukee —Clinical Professor of Medicine	None	None	None	None	None	None

1For the purpose of developing a general cardiovascular training statement, the ACC determined that no relationships with industry or other entities are relevant.
2This table reflects author's employment and reporting categories. To ensure complete transparency, *authors' comprehensive healthcare-related disclosure*
3*information* — including RWI not pertinent to this document — is available online (see Online Appendix 3). Please refer to
4http://www.cardiosource.org/Science-And-Quality/Practice-Guidelines-and-Quality-Standards/Relationships-With-Industry-Policy.aspx for definitions of
5disclosure categories or additional information about the ACC Disclosure Policy for Writing Committees.

APPENDIX 4. PEER REVIEWER RELEVANT RELATIONSHIPS WITH INDUSTRY AND OTHER ENTITIES—COCATS 4 TASK FORCE 7: TRAINING IN CARDIOVASCULAR COMPUTED TOMOGRAPHY

Name	Employment	Representation	Consultant	Speaker's Bureau	Ownership/ Partnership/ Principal	Personal Research	Institutional/ Organizational or Other Financial Benefit	Expert Witness
Richard Kovacs	Indiana University, Krannert Institute of Cardiology—Q.E. and Sally Russell Professor of Cardiology	Official Reviewer, ACC Board of Trustees	None	None	None	None	None	None
Dhanunjaya Lakkireddy	Kansas University Cardiovascular Research Institute	Official Reviewer, ACC Board of Governors	None	None	None	None	None	None
Howard Weitz	Thomas Jefferson University Hospital—Director, Division of Cardiology; Sidney Kimmel Medical College at Thomas Jefferson University —Professor of Medicine	Official Reviewer, Competency Management Committee Lead Reviewer	None	None	None	None	None	None
Kiran Musunuru	Brigham and Women's Hospital, Harvard University	Organizational Reviewer, AHA	None	None	None	None	None	None
Dennis Calnon	OhioHealth Heart and Vascular Physicians—Director, Cardiac Imaging, Riverside Methodist Hospital	Organizational Reviewer, ASNC	None	None	None	None	None	None
Thomas Gerber	Mayo Clinic—Professor, Medicine, Radiology	Organizational Reviewer, SAIP	None	None	None	None	None	None
John Hodgson	Metrohealth Medical Center	Organizational Reviewer, SCAI	None	None	None	None	None	None
Suhny Abbara	University of Texas Southwestern Medical Center —Director, Cardiovascular Imaging Section	Organizational Reviewer, SCCT	None	None	None	None	None	None
Brian D. Hoit	University Hospitals Case Medical Center, Cleveland Ohio	Content Reviewer, Cardiology Training and Workforce Committee	None	None	None	None	None	None
Larry Jacobs	Lehigh Valley Health	Content Reviewer,	None	None	None	None	None	None

	Network, Division of Cardiology; University of South Florida—Professor, Cardiology	Cardiology Training and Workforce Committee						
Andrew Kates	Washington University School of Medicine	Content Reviewer, Academic Cardiology Section Leadership Council	None	None	None	None	None	None
Nishant Shah	Brigham and Women's Hospital, Harvard Medical School—Cardiovascular Imaging Fellow	Content Reviewer, Imaging Council	None	None	None	None	None	None
Kim Williams	Rush University Medical Center—James B. Herrick Professor and Chief, Division of Cardiology	Content Reviewer, Cardiology Training and Workforce Committee	None	None	None	None	None	None

For the purpose of developing a general cardiovascular training statement, the ACC determined that no relationships with industry or other entities are relevant. This table reflects peer reviewers' employment, representation in the review process, as well as reporting categories. Names are listed in alphabetical order within each category of review.

ACC = American College of Cardiology, AHA = American Heart Association, ASNC = American Society of Nuclear Cardiology, SAIP = Society of Atherosclerosis Imaging and Prevention, SCAI = Society for Cardiovascular Angiography and Interventions, and SCCT = Society of Cardiovascular Computed Tomography.

References