

## ADVANCED TRAINING STATEMENT

# 2021 ACC/AHA/SVM/ACP Advanced Training Statement on Vascular Medicine (Revision of the 2004 ACC/ACP/SCAI/SVMB/SVS Clinical Competence Statement on Vascular Medicine and Catheter-Based Peripheral Vascular Interventions)

A Report of the ACC Competency Management Committee

Developed in Collaboration With the Association of Black Cardiologists, Society for Cardiovascular Angiography and Interventions, Society for Vascular Nursing, and the Society for Vascular Surgery

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## PREAMBLE

Since publication of its first Core Cardiovascular Training Statement (COCATS) in 1995,<sup>1</sup> the American College of Cardiology (ACC) has defined the knowledge, experiences, skills, and behaviors expected of clinical cardiologists. Subsequent revisions have moved toward competency-based training based on 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). The ACC has taken a similar approach to describe the aligned general cardiology lifelong learning competencies that practicing cardiologists are expected to maintain. Many hospital systems now use the 6-domain structure as part of medical staff privileging, peer review, and professional competence assessments.

Whereas COCATS and the associated Lifelong Learning Competencies for General Cardiologists<sup>2</sup> focus on general clinical cardiology, ACC Advanced Training Statements and associated Lifelong Learning Statements define selected competencies beyond those expected of all cardiologists and that typically require training beyond

a standard 3-year cardiovascular disease fellowship. This includes, but is not limited to, those disciplines for which there is an ABIM subspecialty certification. The Advanced Training Statements describe key experiences and outcomes necessary to acquire skills in a defined subspecialty area of cardiology in a structured training program. These are supplemented by Lifelong Learning Statements that address the commitment to sustaining and enriching competency over the span of a career.

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 to ensure adequate exposure to the range of clinical disorders, the objective assessment of proficiency and outcomes demonstrates the achievement of competency. Evaluation tools include examinations, direct observation, procedure logbooks, simulation, conference presentations, and multisource (360°) evaluations. For practicing physicians, these tools also include professional society registry or hospital quality data, peer review processes, and patient satisfaction surveys. A second feature of competency-based training is recognition that learners gain competency at different rates. For multi-year training programs, assessment of representative curricular milestones during training can identify learners or areas that require additional focused attention.

The recommendations in ACC Cardiovascular Training and Lifelong Learning Statements are based on available evidence and, where evidence is lacking, reflect consensus expert opinion. The writing committees are broad-based, and typically include early-, mid-, and later-career specialists; general cardiology and subspecialty training directors; practicing cardiologists; people working in institutions of various sizes and in diverse practice settings across the United States; and nonphysician members of the cardiovascular care team. All documents undergo a rigorous process of peer review and public comment. Recommendations are intended to guide the assessment of competence of cardiovascular care providers beginning independent practice as well as those undergoing periodic review to ensure that competence is maintained.

This Advanced Training Statement addresses the core competencies required of vascular medicine specialists and complements the training in vascular medicine required of all physician trainees during the standard 3-year general cardiovascular fellowship. Furthermore, this statement identifies selected competencies of vascular medicine specialists that go beyond core expectations that may be achieved by some advanced trainees either during formal fellowship training or through subsequent training experiences. This document provides examples of appropriate measures for assessing competence in the context of training.

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 resulting from relationships with industry (RWI) or other entities held by writing committee members or peer reviewers of the document, individuals were 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 (currently marketed or under development) pertinent to the document topic. Based on this information, the writing committee was selected to ensure that the chair and a majority of members had no relevant RWI. RWI was reviewed at the start of all meetings and conference calls and updated as changes occurred. Relevant RWI for authors is disclosed in Appendix 1. To ensure transparency, comprehensive RWI for authors, including RWI not pertinent to this document, is posted in [Supplemental Appendix I](#). Employment information and affiliations of the peer reviewers are shown in Appendix 2. There are no RWI restrictions for participation in peer review, in the interest of encouraging comments from a variety of constituencies to ensure that a broad range of viewpoints inform final document content. Reviewers are required, however, to disclose all healthcare-related RWI and other entities, and their disclosure information is posted in [Supplemental Appendix II](#). Disclosure information for the ACC Competency Management Committee is available [online](#) as well as 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 the ACC, American Heart Association (AHA), American College of Physicians (ACP), Society for Vascular Medicine (SVM), Association of Black Cardiologists, Society for Cardiovascular Angiography and Interventions, Society for Vascular Nursing, and Society for Vascular Surgery. Each performs at least 1 of the following roles: 1) vascular medicine specialists who work in academic and/or community-based practice settings, and who represent early to late career professionals; 2) training program directors

of vascular medicine and of cardiovascular medicine; and 3) other specialists representing general cardiology, interventional cardiology, vascular surgery, vascular nursing, vascular research, and advanced practice nurses. The writing committee also included 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. This writing committee met the College's disclosure requirements for RWI as described in the Preamble.

#### 1.1.2. Document Development and Approval

The writing committee convened by conference call and email 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.

The document was reviewed by 18 official representatives from the ACC, AHA, ACP, SVM, Association of Black Cardiologists, Society for Cardiovascular Angiography and Interventions, Society for Vascular Nursing, and the Society for Vascular Surgery, as well as by 25 additional content reviewers (see Appendix 2). The document was simultaneously posted for public comment from February 26, 2020, to March 11, 2020. A total of 409 comments were submitted on the document. All 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 ACC, AHA, ACP, and SVM approved the document for publication with endorsement from the Association of Black Cardiologists, Society for Cardiovascular Angiography and Interventions, Society for Vascular Nursing, and Society for Vascular Surgery. 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 American College of Cardiology recommendations for training in adult cardiology evolved from a Core Cardiology Training Symposium.<sup>1</sup> After several iterations, COCATS 4 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.<sup>3</sup> 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.

COCATS 4 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. The Task Force 9 report of that document addressed training in vascular medicine and updated previous standards for general cardiovascular training for fellows enrolled in cardiovascular fellowship programs.<sup>4</sup> It addressed faculty, facilities, equipment, and ancillary support. It also addressed training components, including didactic, clinical, and hands-on experience, and the number of procedures and duration of training to acquire core Level I and II competencies in vascular medicine. Importantly, the COCATS 4 Task Force 9 report did not provide detailed guidelines for Level III training in vascular medicine, but described it in broad terms to provide context for trainees and clarify that these advanced competencies are not covered during the cardiovascular fellowship. Given the burden of vascular diseases, it is critical that trainees in cardiovascular medicine receive appropriate training in vascular medicine as described in COCATS 4 and have the opportunity to pursue advanced training in this field.

This Advanced Training Statement focuses on training requirements for physicians seeking additional training in vascular medicine. It describes the pathway in which these advanced skills are acquired following a cardiovascular fellowship, but it can also be applied to trainees who pursue advanced training in vascular medicine without first specializing in cardiovascular medicine. Training requirements for physicians seeking competency in endovascular interventions will be addressed in a future advanced training statement.

### **1.2.1. Evolution of Vascular Medicine**

The responsibilities of vascular medicine physicians range from preserving vascular health and treating vascular diseases to advancing vascular science. Although cardiovascular physicians frequently encounter and care for patients with a wide range of arterial and venous disorders, the management of vascular disease often necessitates highly trained specialists. Advances in imaging techniques, novel antithrombotic and lipid lowering drugs, and endovascular therapies have increased the range of therapeutic options for patients with vascular diseases. In addition, vascular disorders require a distinct set of knowledge and skills for optimal management. This document provides the framework for training in this rapidly evolving field.

### **1.2.2. Levels of Training**

COCATS 4 updated standards for training fellows in Cardiovascular Medicine and established consistent training criteria across all aspects of general cardiology, including vascular medicine.<sup>3</sup> For the cardiovascular fellowship, the

following 3 levels of training are delineated for training in vascular medicine.

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. All cardiovascular fellows should receive basic training in vascular medicine and acquire sufficient knowledge to care for many patients with peripheral vascular diseases.

Level II training, also described in COCATS 4, refers to additional training 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. In the case of vascular medicine, Level II training can be elected by fellows seeking additional expertise in interpreting noninvasive diagnostic tests and evaluating and managing patients with peripheral vascular diseases. Level II training is also recommended prior to or in conjunction with training in catheter-based peripheral vascular intervention (see COCATS 4 Task Force 10 report<sup>5</sup>).

Level III training, the primary focus of this document, requires training and experience beyond the cardiovascular fellowship for the acquisition of specialized knowledge and competency to render advanced care for patients with specific conditions. In the case of vascular medicine, Level III training pertains to advanced knowledge in diagnostic and therapeutic modalities for evaluating and managing vascular disease and leads to the ability to direct a vascular laboratory, train others, and conduct advanced research in vascular medicine.

## **2. GENERAL STANDARDS**

### **2.1. Faculty**

Engaged faculty who are committed to teaching vascular medicine are critical to the success of an advanced vascular training program. Trainees should be exposed to individuals with advanced training in vascular medicine. In most institutions, the training program will be directed by a vascular medicine specialist who has met the Level III qualifications described in this document. In institutions where there is not a vascular medicine specialist, the training program may be coordinated by cardiologists, hematologists, neurologists, vascular surgeons, or vascular interventionalists. Key faculty members responsible for training fellows in vascular medicine should be board certified in their subspecialties. Vascular medicine training programs are encouraged to include faculty from relevant specialties, including vascular surgery, vascular radiology

(diagnostic and interventional), hematology, neurology, dermatology, wound care, and rheumatology, which allows for a diverse and comprehensive training experience. Faculty should be committed to providing didactic and practical training spanning the topics of fundamental vascular pathophysiology; noninvasive and invasive diagnostic approaches; and the medical, interventional, and surgical management of patients with peripheral vascular disease. An emphasis on faculty who can support scholarly activity is encouraged, so that fellows can gain exposure to academic research.

## 2.2. Facilities

Training institutions should provide comprehensive facilities for the care of patients with vascular disease, including offices for outpatient evaluation and treatment as well as inpatient vascular consultative services. Institutions should also have an accredited noninvasive vascular laboratory and facilities for computed tomographic angiography, magnetic resonance (MR) angiography, and a safe and sterile environment for performing peripheral vascular catheterization and endovascular interventions. Comprehensive vascular surgery and wound care programs and facilities for supervised exercise rehabilitation should also be available.

## 2.3. Equipment

Noninvasive vascular laboratories require dedicated equipment to perform diagnostic studies, including duplex ultrasound units capable of high-resolution B-mode (grayscale) imaging as well as color and spectral Doppler analysis, equipment for physiological testing with appropriately sized cuffs to measure blood pressure at multiple sites in the limbs, Doppler and plethysmographic devices (eg, pulse volume recordings, photoplethysmographic sensors), and equipment for digital image recording and archiving. Equipment required for cardiovascular computed tomography (CT), cardiovascular MR, and catheter-based angiography is discussed in the COCATS 4 Task Force 7, 8, and 10 reports, respectively.<sup>5-7</sup>

## 2.4. Additional Resources

Level III trainees should communicate with additional personnel to ensure comprehensive, evidence-based care. Critical to success is collaborative interaction with various physicians from within the cardiovascular community, including vascular specialists, interventionalists, advanced imaging specialists, and other fields, in order to address and treat the multiple comorbidities often seen in patients with vascular disease. Key specialties include—but are not limited to—cardiac and vascular surgeons; nephrologists; hematologists; pulmonologists;

neurologists; podiatrists; infectious disease specialists; cardiovascular genetic counselors; vascular sonographers; and experts in wound care, lymphatic decompression, exercise rehabilitation, prosthetics, and mobility aides. In addition, communication with primary care physicians, geriatricians, pediatricians, obstetricians, endocrinologists, and oncologists is important for specific patient populations. Also essential is interaction with other vital healthcare professionals, including nurse practitioners, physician assistants, nurses, pharmacists, dietitians, physical and occupational therapists, and social workers.

## 3. TRAINING COMPONENTS

### 3.1. Didactic Program

Didactic activities for Level III trainees should include a variety of formats, including lectures, online modules, journal clubs, grand rounds, clinical case presentations, research conferences, simulator-based training, and patient safety or quality improvement conferences. The educational content should cover vascular topics, including—but not limited to—peripheral artery disease; renal artery stenosis; mesenteric vascular disease; cerebrovascular disease; aneurysmal disease of the aorta and peripheral arteries; acute aortic syndromes; vasculitis; vasospastic and temperature-related diseases; venous thromboembolism; chronic venous insufficiency and varicose veins; lymphedema; less-common disorders such as fibromuscular dysplasia and arteriopathies associated with inherited diseases of connective tissue; congenital vascular malformations and arterial entrapment syndromes; vascular ulcers of the extremities; and the preoperative evaluation and perioperative management of patients undergoing vascular surgery. Educational content should also cover the noninvasive vascular laboratory, including principles of vascular physiology, ultrasound physics, vascular ultrasound imaging, Doppler flow velocity measurements, blood pressure measurement and pulse volume recordings, transducer technology, imaging artifacts, and the noninvasive evaluation of specific vascular diseases. Topics relevant to directing a noninvasive vascular laboratory should be covered, including budgeting, manpower, and equipment assessment, accreditation, RWI, sonographer supervision, and continuous quality improvement. Lectures and case presentations should cover other vascular imaging modalities such as MR, computed tomographic, and catheter-based angiography. The lecture series should include regularly scheduled patient safety or quality improvement conferences and journal clubs. There should be other forums for interactive discussion of the established literature and emerging scientific advances. Interaction with vascular

specialists from other disciplines at these conferences is recommended.

### 3.2. Clinical Experience

Level III training in vascular medicine should provide the knowledge and skills to function as a vascular specialist, including the ability to interpret patients' clinical presentation, plan diagnostic testing, apply clinical and laboratory information, and develop appropriate management plans for patients across the entire range of vascular diseases. This includes—but is not limited to—peripheral artery disease, renal artery disease, mesenteric vascular disease, cerebrovascular disease, aneurysmal disease of the aorta and peripheral arteries, acute aortic syndromes, vasculitis, venous thromboembolism, chronic venous insufficiency, varicose veins, lymphedema, extremity ulcers, vasospastic, temperature-related disorders, and less common vascular disorders. Trainees should acquire skills in the use of pharmacotherapy to prevent and treat atherosclerosis, venous thromboembolism, and associated risk factors; understand the roles of exercise rehabilitation and endovascular and surgical revascularization in management of patients with vascular disease; be capable of assessing cardiovascular risk; and be knowledgeable about periprocedural/perioperative management of patients undergoing endovascular procedures and vascular surgery. These skills should be obtained through patient engagement in ambulatory and inpatient settings.

Trainees should have dedicated time and experience in the noninvasive vascular laboratory to acquire skills in the performance and interpretation of noninvasive vascular tests, including physiological and ultrasound vascular testing, segmental pressure measurements, pulse volume recordings, and duplex ultrasonography, for venous thrombosis, venous insufficiency, peripheral artery disease, abdominal aortic aneurysm, renal and mesenteric artery disease, and cerebrovascular disease (see Section 3.3). The program also should ensure experience to acquire knowledge related to the other vascular diagnostic modalities (eg, MR, computed tomographic angiography, invasive angiography). Whereas Level III training in vascular medicine is not intended to provide the knowledge and skills to perform endovascular interventions, it is expected that trainees will have sufficient experience in a laboratory that performs diagnostic angiography and peripheral endovascular interventions to understand their use in the management of patients with vascular disease. It is also expected that trainees will have exposure to open vascular surgeries and the postoperative management of these patients.

### 3.3. Hands-On Procedural Experience

Level III trainees in vascular medicine will have acquired some hands-on procedural skills through

prior Level I and II training, including skills to perform a detailed vascular physical examination, measurement of the ankle-brachial index, as well as additional skills as discussed in the COCATS 4 document.<sup>4</sup> Advanced training in vascular medicine builds upon these previously acquired hands-on and procedural skills to include evaluation and management of rare and complex pathologies and development of skills for history taking and physical examination for these disorders. Building upon experience in measuring the ankle-brachial index, the Level III trainee should develop experience in using the handheld Doppler as an adjunct to the physical examination for bedside evaluation of extremity arteries and veins.

All Level III trainees should have extensive experience in the vascular laboratory in the interpretation of noninvasive vascular studies (see Section 4.2.8). Some trainees with prior Level II training in vascular medicine may have already certified as a Registered Physician in Vascular Interpretation (RPVI).<sup>8</sup> During the advanced training program, time should be dedicated to acquisition of advanced interpretive skills, hands-on scanning exposure, and development of requisite skills to serve as the medical director of a noninvasive vascular laboratory. All Level III trainees should have significant hands-on experience in the performance of routine noninvasive vascular diagnostic studies, including carotid, renal, venous, mesenteric, aortic, and extremity arterial duplex ultrasonography, and hands-on experience in performing multilevel noninvasive physiological examinations at rest and with exercise. Such hands-on experience should include optimization of image acquisition. This hands-on experience in the vascular laboratory should be coordinated by an experienced and certified technologist/sonographer mentor (ie, registered vascular technologist [RVT] or equivalent credential) or a faculty mentor with extensive experience in vascular scanning as well as study interpretation. While it is not expected that Level III trainees will acquire adequate hands-on scanning experience and test volume to function independently as a technologist, it is important that Level III trainees have fundamental skills in performing noninvasive diagnostic tests in order to critically evaluate images for interpretation. These skills also help trainees address questions from the technologists in challenging cases and allow the Level III trainee to help train future technologists and medical staff when they start a vascular laboratory. Trainees may also acquire hands-on experience in management of post-catheterization complications during Level III training, including ultrasound-guided thrombin injection of post-catheterization pseudoaneurysms.

All Level III trainees will acquire hands-on skills in the management of swollen limbs due to chronic venous insufficiency and lymphedema as well as in the management of uncomplicated lower extremity wounds,

including compression therapy management, indications for debridement, and dressing selection. With additional clinical rotations and hands-on experience, Level III trainees may acquire skills to manage complex lower extremity wounds, including care of wounds related to severe peripheral artery disease (PAD) (ie, critical limb ischemia) as part of a limb-salvage team, performance of mechanical debridement (when indicated), and use of adjunctive wound healing therapies (eg, negative pressure wound dressings). In addition to advanced wound care techniques, some individuals may pursue additional specialized training in procedural management of superficial venous disease during the vascular medicine fellowship, including hands-on training in sclerotherapy, chemical and thermal ablation, and ambulatory phlebectomy.

### 3.4. Diagnosis and Management of Emergencies and Complications

All trainees should know how to diagnose and manage acute vascular emergencies, including acute aortic syndromes, arterial dissection, acute limb ischemia, pulmonary embolism, acute venous thrombosis including phlegmasia cerulea dolens, complications of renal artery stenosis, acute mesenteric ischemia, transient ischemic attack or stroke in a patient with carotid artery disease, vascular access site complications, and bleeding complications of antithrombotic therapies. Often, management involves referral to other specialists, such as interventional cardiologists, interventional radiologists, or vascular surgeons, for advanced therapies.

### 3.5. Diagnosis and Management of Less Common Clinical Conditions and Syndromes

Vascular medicine trainees should be familiar with the less common vascular conditions they may encounter in their practice and when these conditions should be considered in the differential diagnosis of more common vascular diseases. These include—but are not limited to—vasculitis, fibromuscular dysplasia, arteriopathies associated with inherited diseases of connective tissue, entrapment syndromes, adventitial cystic disease, environmental and thermal-associated vascular diseases, and congenital vascular anomalies.

### 3.6. Research and Scholarly Activity

All trainees are encouraged to participate in research and scholarly activities during their vascular medicine fellowship. In some programs, these activities will occur concurrently with the clinical training; other programs will include an additional year or more of dedicated research. The scholarly activities can cover any topic related to vascular disease, including—but not limited to—atherosclerosis,

thrombosis, aneurysm disease, venous/lymphatic disease, and vascular biology, and may include original basic, clinical, translational, population, health services, or health disparities research. Trainees are encouraged to present their work at regional and national meetings, and importantly are expected to disseminate their findings in high-quality, peer-reviewed journals. Case reports, book chapters, and review articles are also acceptable but should not replace original research. Trainees interested in academic careers in research should participate in activities geared toward acquiring skills to design, conduct, analyze, and interpret research as well as workshops or courses to enhance capabilities in grant and manuscript writing. All trainees are encouraged to develop and maintain habits of self-learning and continuous professional improvement through reading published literature, attending journal clubs and conferences, and participating in relevant scholarly meetings. A trainee's progress in research should be monitored by the program director and the fellow's faculty mentor, with metrics of success (eg, presentations, manuscripts, submitted grants) clearly specified at the beginning of the training program.

## 4. TRAINING REQUIREMENTS

### 4.1. Development and Evaluation of Core Competencies

Training requirements in vascular medicine address the 6 general competencies promulgated by the ACGME 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 cardiovascular medicine. 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 milestones reported to ACGME. The ACC has adopted this format for its competency and training statements, career milestones, lifelong learning, and educational programs.

Table 1 depicts the Medical Knowledge competencies and Patient Care and Procedural Skill competencies specifically related to vascular medicine, as well as examples of evaluation tools suitable for assessing competence in each domain. The focus of this document is on delineation of the core competencies expected of all trainees upon successful completion of a 1-year advanced vascular medicine fellowship. These competencies are marked under the column "all." However, certain areas of advanced knowledge or procedural skills are not typically encountered enough during a standard 12-month period of training to develop and demonstrate competence and

**Table 1. Competency Components and Curricular Milestones for Level III Training in Vascular Medicine**

Medical Knowledge		Milestones	
		All	Add*
1	Know the anatomy of the peripheral arterial, venous, and lymphatic systems.	X	
2	Know the basic vascular biology of atherosclerosis and thrombosis.	X	
3	Know the indications for and contraindications, benefits, risks, and clinical pharmacology of drugs used to prevent and treat atherosclerotic vascular diseases.	X	
4	Know the indications for and contraindications, benefits, risks, and clinical pharmacology of drugs used to prevent and treat arterial and venous thrombotic disorders.	X	
5	Know the appropriate indications and laboratory tests to assess for inherited and acquired thrombophilia.	X	
6	Know the treatment strategies to achieve smoking cessation.	X	
7	Know the pathophysiology, causes, and clinical epidemiology of upper and lower extremity ulcers.	X	
8	Know the principles of and indications for vascular duplex ultrasound, including physics, blood flow, continuous and pulsed wave Doppler, color Doppler, and grayscale imaging.	X	
9	Know the principles of and indications for arterial and venous physiological studies (eg, segmental pressures, pulse volume recording, plethysmography).	X	
10	Know the role of advanced imaging (eg, computed tomography, magnetic resonance imaging, positron emission tomography) in the evaluation and management of patients with vascular diseases.	X	
11	Know the indications for and contraindications, benefits, and risks of invasive angiography and venography.	X	
12	Know the indications for and contraindications, benefits, and risks of endovascular and open vascular surgical procedures.	X	
13	Know the pathophysiology, clinical epidemiology, risk stratification, and management of vascular disorders associated with pregnancy and the postpartum period (eg, venous thromboembolism, aortic aneurysm, spontaneous coronary artery dissection, aortic dissection, amniotic fluid embolism).	X	
14	Know the pathophysiology, clinical epidemiology, and management of vascular complications of cancer and cancer therapies.		X
15	Know the strategies to improve vascular health equity by understanding sex, race, and ethnicity-related differences in clinical epidemiology, causes, and outcomes of vascular disease.	X	
Peripheral Artery Disease			
16	Know the pathophysiology, causes, and clinical epidemiology of lower and upper extremity peripheral artery disease (eg, asymptomatic, intermittent claudication, functional impairment, critical limb ischemia, acute limb ischemia), including risk factors.	X	
17	Know the pathophysiology, causes, and clinical epidemiology of nonatherosclerotic arterial diseases of the extremities, including thromboembolic disease, atheroembolism, vasculitis, cystic adventitial disease, compression syndromes, endofibrosis, fibromuscular dysplasia, thromboangiitis obliterans, peripheral aneurysms, and dissection.	X	
18	Know the symptoms and physical findings of peripheral artery disease, including atypical symptoms, claudication, critical limb ischemia, and acute limb ischemia.	X	
19	Know the indications and methods for diagnosis of patients with suspected peripheral artery disease.	X	
20	Know the medical therapies and lifestyle modifications to reduce cardiovascular risk in patients with peripheral artery disease.	X	
21	Know the medical therapies to reduce limb symptoms and adverse limb events in patients with peripheral artery disease.	X	
22	Know the components of and indications for supervised exercise therapy for claudication.	X	
23	Know the indications and methods for diagnosis of patients with symptomatic peripheral artery disease.	X	
24	Know the indications for endovascular and surgical revascularization for patients with peripheral artery disease.	X	
25	Know the indications and imaging methods for surveillance after endovascular and surgical revascularization in patients with peripheral artery disease.	X	
26	Know the symptoms, physical findings, and diagnostic approaches to peripheral vascular entrapment syndromes, including thoracic outlet syndrome and popliteal artery entrapment syndrome.	X	
Renal and Mesenteric Artery Disease			
27	Know the pathophysiology, causes, and clinical epidemiology of acute and chronic renal and mesenteric artery disease, including atherosclerotic and nonatherosclerotic diseases (eg, fibromuscular dysplasia, nutcracker syndrome, median arcuate ligament syndrome), and visceral artery aneurysms and dissection.	X	
28	Know the symptoms and physical findings of acute and chronic renal and mesenteric arterial diseases.	X	
29	Know the pathophysiology of hypertension, kidney disease, and heart failure in patients with renal artery disease.	X	
30	Know the indications and methods for diagnosis of renal artery disease.	X	
31	Know the indications for invasive angiography, angioplasty and stenting, and surgical bypass in patients with renal artery disease.	X	
32	Know the indications and methods to diagnose mesenteric arterial disease.	X	
33	Know the indications for invasive angiography, angioplasty and stenting, and surgical bypass in patients with mesenteric artery disease.	X	

(Continued)



**Table 1. Continued**

Medical Knowledge		Milestones	
		All	Add*
34	Know the management of visceral artery aneurysms, including identification of patients for whom surgical or endovascular repair is indicated.	X	
35	Know the methods for follow-up after a patient has undergone renal or mesenteric arterial revascularization.	X	
Cerebrovascular Disease			
36	Know the pathophysiology, causes, and clinical epidemiology of cerebrovascular disease, including atherosclerotic and nonatherosclerotic diseases (eg, fibromuscular dysplasia, dissection, aneurysm, carotid body tumor).	X	
37	Know the symptoms and physical findings of cerebrovascular diseases.	X	
38	Know the methods for diagnosis of asymptomatic and symptomatic carotid artery disease.	X	
39	Know the diagnosis and management strategies for patients with subclavian steal syndrome.	X	
40	Know the risk stratification strategies, lifestyle modifications, and medical therapies to reduce risk of stroke in patients with cerebrovascular disease.	X	
41	Know the indications for endovascular and surgical revascularization for subclavian, vertebral, and carotid artery disease.	X	
42	Know the anticoagulation strategies for stroke prevention in patients with atrial fibrillation and other causes of cardioembolism.	X	
43	Know the periprocedural management strategies for patients who undergo carotid revascularization.	X	
44	Know the indications and imaging methods for surveillance and evaluation of patients after carotid revascularization.	X	
Aortic Diseases			
45	Know the pathophysiology, causes, and clinical epidemiology of aortic diseases, including acute aortic syndromes, atherosclerotic aortic disease, and aortic aneurysms.	X	
46	Know the symptoms and physical findings of thoracic and abdominal aortic aneurysms and acute aortic syndromes, including dissection, intramural hematoma, and penetrating atherosclerotic ulcer.	X	
47	Know the methods for initial evaluation and management of patients with acute aortic syndromes, including indications for emergency surgical or endovascular repair.	X	
48	Know the methods for surveillance, evaluation, and management of patients with prior acute aortic syndromes, including indications for surgical or endovascular repair.	X	
49	Know the indications for screening for thoracic, abdominal, and peripheral arterial aneurysms.	X	
50	Know the indications for and benefits, risks, and expected outcomes of surgical and endovascular treatments for acute aortic syndromes.	X	
51	Know the indications for and benefits, risks, and expected outcomes of surgical and endovascular treatments for aortic dissection, aortic aneurysm, and peripheral aneurysms.	X	
52	Know the indications and imaging methods for surveillance, evaluation, and management of patients who have undergone thoracic or abdominal aortic endovascular repair.	X	
Vasculitis, Vasospastic, and Temperature-Related Disorders			
53	Know the pathophysiology, causes, and clinical epidemiology of large-, medium-, and small-vessel vasculitis.	X	
54	Know the symptoms and physical findings of large-, medium-, and small-vessel vasculitis.	X	
55	Know the differential diagnosis and evaluation of vasculitis.	X	
56	Know the principles of medical management of vasculitis.	X	
57	Know the indications for and contraindications, risks, and clinical pharmacology of drugs used to treat vasculitis.		X
58	Know the indications for referring patients with vasculitis for invasive angiography and revascularization procedures.	X	
59	Know the evaluation and management of patients with thromboangiitis obliterans.	X	
60	Know the pathophysiology, causes, and clinical epidemiology of vasospastic disorders such as Raynaud phenomenon and other temperature-related disorders of blood vessels, including acrocyanosis, erythromelalgia, and pernio.	X	
61	Know the symptoms and physical findings of vasospastic disorders such as Raynaud phenomenon and other temperature-related disorders of blood vessels, including acrocyanosis, erythromelalgia, and pernio.	X	
62	Know the evaluation, diagnostic approach, and therapies for Raynaud phenomenon, acrocyanosis, erythromelalgia, and pernio.	X	
63	Know the indications for and contraindications, benefits, risks, and clinical pharmacology of drugs used for Raynaud phenomenon, acrocyanosis erythromelalgia, and pernio.	X	
Acute and Chronic Venous Diseases			
64	Know the pathophysiology, causes, and clinical epidemiology of deep venous thrombosis and pulmonary embolism.	X	
65	Know the pathophysiology, causes, and clinical epidemiology of superficial vein thrombosis.	X	
66	Know the pathophysiology, causes, and clinical epidemiology of chronic venous insufficiency and varicose veins.	X	
67	Know the symptoms and physical findings of deep venous thrombosis and pulmonary embolism.	X	

(Continued)

**Table 1. Continued**

Medical Knowledge		Milestones	
		All	Add*
68	Know the symptoms and physical findings of chronic venous insufficiency and varicose veins.	X	
69	Know the symptoms and physical findings of less common venous thrombosis, including cerebral sinus vein thrombosis, splanchnic vein thrombosis, and mesenteric vein thrombosis.	X	
70	Know the methods for risk assessment and diagnosis of deep venous thrombosis and pulmonary embolism.	X	
71	Know the methods for diagnosis of chronic venous insufficiency and varicose veins.	X	
72	Know the methods for diagnosing less common venous thrombosis, including cerebral sinus vein thrombosis, splanchnic vein thrombosis, and mesenteric vein thrombosis.	X	
73	Know the indications for and contraindications, benefits, risks, and clinical pharmacology of drugs to prevent and treat deep venous thrombosis and pulmonary embolism.	X	
74	Know the indications for and contraindications, benefits, and risks of thrombolytic therapy for deep venous thrombosis and pulmonary embolism.	X	
75	Know the indications for referring patients with venous thrombosis and pulmonary embolism for advanced therapies (eg, catheter-directed thrombolysis/thrombectomy, surgical thrombectomy/embolectomy).	X	
76	Know the indications for and contraindications, benefits, and risks of inferior vena cava filters for deep venous thrombosis and pulmonary embolism.	X	
77	Know the evaluation and management of patients with chronic thromboembolic pulmonary hypertension.	X	
78	Know the evaluation and management of patients with venous compression syndromes, including May-Thurner, thoracic outlet, nutcracker, and pelvic congestion syndromes.	X	
79	Know the management of patients with varicose veins, venous insufficiency, and venous ulcers.	X	
80	Know the indications for referring patients with chronic venous insufficiency for interventional therapies.	X	
Lymphatic Diseases and Lipedema			
81	Know the pathophysiology, causes, and clinical epidemiology of lymphedema.	X	
82	Know the symptoms and physical findings of lymphedema.	X	
83	Know the indications for diagnostic testing for lymphedema (eg, lymphoscintigraphy).		X
84	Know the differential diagnosis and evaluation of lower and upper extremity swelling (eg, venous insufficiency, lipedema, congestive heart failure).	X	
85	Know the indications to refer patients for comprehensive decongestive therapy, including manual lymphatic drainage, compression therapy, and surgical approaches for lymphedema.	X	
86	Know the pathophysiology, causes, and clinical epidemiology of lipedema.	X	
87	Know the symptoms and physical finding of lipedema.	X	
88	Know the medical treatments and indications to refer patients for surgical approaches for treating lipedema.		X
<i>Evaluation Tools:</i> chart-stimulated recall and direct observation			
Patient Care and Procedural Skills		Milestones	
		All	Add*
1	Skill to conduct a vascular history.	X	
2	Skill to perform physical examinations, including maneuvers for the evaluation of arterial, venous, and lymphatic diseases.	X	
3	Skills to perform and interpret ankle-brachial index (ABI) assessment using a hand-held Doppler device.	X	
4	Skill to treat venous insufficiency using compressive therapies.	X	
5	Skill to manage nonhealing wounds, including debridement techniques, dressing selection, and selection of adjunctive wound healing therapies.		X
6	Skill to perform preprocedural risk assessment for patients undergoing endovascular and open vascular surgical procedures.	X	
7	Skill to manage lymphedema with compression therapy.	X	
8	Skill to perform manual lymphatic therapy.		X
9	Skills to evaluate and manage lower extremity ulcers, including indications for adjunctive imaging and biopsy, indications and techniques for debridement, and selection of dressings.	X	
10	Skills to implement and oversee a supervised exercise program for patients with peripheral artery disease.	X	
11	Skill to evaluate vascular anatomy from imaging modalities (eg, ultrasound, computed tomographic angiography, magnetic resonance angiography).	X	
12	Skill to treat femoral pseudoaneurysm with ultrasound-guided compression therapy or ultrasound-guided thrombin injection.		X
13	Skill to perform sclerotherapy, venous ablation, and phlebectomy to treat patients with superficial venous disease.		X

(Continued)

**Table 1. Continued**

Patient Care and Procedural Skills		Milestones	
		All	Add*
Noninvasive Diagnostic Tests			
14	Skills to acquire and interpret duplex ultrasound of carotid, renal, mesenteric, aortic, and extremity arteries, including stents and aortic endografts.	X	
15	Skills to acquire and interpret duplex ultrasound of lower and upper extremity veins.	X	
16	Skills to acquire and interpret noninvasive arterial physiological studies of the extremities at rest and with exercise.	X	
17	Skills to acquire and interpret duplex ultrasound and physiological studies prior to and for vascular access for dialysis.	X	
18	Skills to perform maneuvers in the vascular laboratory for assessment of arterial and venous diseases and interpret the results.	X	
19	Skills to acquire and interpret duplex ultrasound for evaluating postprocedural vascular complications, including arteriovenous fistula, pseudoaneurysm, dissection, and hematoma.	X	
20	Skills to acquire and interpret vascular imaging for detection of subclinical arterial disease, including carotid-intima medial thickness, flow-mediated dilation, and arterial stiffness.		X
21	Skills to acquire and interpret transcranial Doppler testing.		X
<i>Evaluation Tools:</i> chart-stimulated recall, direct observation, and multisource evaluation			

\*Add indicates additional competencies that extend beyond the core expectations that may be achieved by some Level III–trained vascular medicine specialists based on career focus, either during or following formal fellowship training (see text for details).

therefore require additional dedicated exposure. These selected Level III competency components are designated in the “add” column of Table 1, and usually require additional training. These additional competencies may be obtained during or after the standard vascular medicine fellowship, depending on the trainee’s career focus and the opportunities available at the training program. Although the competency components included in the “all” column 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.

Table 2 specifies a common set of professional behavior competencies that fall under the ACGME competency domains entitled Systems-Based Practice, Practice-Based Learning and Improvement, Interpersonal and Communication Skills, and Professionalism. Although these competencies are relevant to all clinical cardiovascular disease specialists, they should be interpreted within the context of vascular medicine practice.

## 4.2. Vascular Medicine

Arterial, venous, and lymphatic disorders are common and induce substantial morbidity and mortality. The comprehensive management of all vascular disorders is the goal of Level III training in vascular medicine. All trainees should be able to manage acute and chronic vascular disorders in both the inpatient and outpatient setting, including initial evaluation and ongoing care. Core areas of knowledge include the anatomy, vascular biology, clinical pharmacology, epidemiology,

pathophysiology, and treatment of diverse vascular diseases. In addition, vascular medicine trainees should understand the principles of vascular duplex and physiology testing and be familiar with the role of advanced imaging, angiography, and revascularization procedures.

### 4.2.1. Peripheral Artery Disease

Given the growth of the aging population in the United States along with the known morbidity and mortality of PAD, it is crucial that vascular medicine trainees understand the pathophysiology, causes, epidemiology, risk factors, and symptoms of the disease such as claudication. In particular, trainees must be able to recognize the manifestations of the most severe forms of disease, acute and chronic critical limb ischemia, including pain in the limbs at rest, loss of lower extremity pulses, a nonhealing wound, or gangrene. PAD is diagnosed with the ankle-brachial index and toe brachial index.<sup>9</sup> Trainees are expected to know the indications for different tests, how to perform them, and how to interpret them.<sup>10</sup> Training requirements also include knowing the indications and limitations for the imaging modalities to diagnose these disorders (ie, duplex ultrasound, CT angiography, MR angiography, and catheter-based angiography). A trainee who has achieved competence in the vascular management of PAD should be knowledgeable about the current ACC/AHA recommendations for medical, endovascular, surgical, and exercise therapies and their application for the treatment of patients with PAD.<sup>10</sup>

### 4.2.2. Renal and Mesenteric Artery Disease

It is important for trainees to understand the anatomy, physiology, and various disease states that may affect renal and visceral circulations. The most common

**Table 2. Common Professional Behavior Competencies to All Clinical Cardiovascular Disease Specialists**

Systems-Based Practice		All Specialists
1.	Incorporate risk-benefit analysis, cost, resource, and value considerations into care of patients with cardiovascular disease.	X
2.	Identify and address financial, cultural, and social barriers to adherence with patient care recommendations, including social determinants of health.	X
3.	Participate in practice-based continuous quality improvement and safety initiatives.	X
4.	Maintain continuity of care with efficient and effective handoffs through transitions of care.	X
5.	Refer patients for new therapies, including consideration of participation in clinical trials.	X
6.	Participate in hospital-based and regional systems of care for patients with urgent and emergency cardiovascular conditions.	X
7.	Collaborate with all cardiovascular care team members to reduce avoidable hospitalizations for cardiovascular disease.	X
8.	Collaborate with physicians and healthcare professionals in other disciplines to optimize the care of patients with complex and multisystem disease.	X
<i>Evaluation Tools:</i> chart-stimulated recall, direct observation, multisource evaluation		
Practice-Based Learning and Improvement		All Specialists
1.	Identify personal knowledge gaps and seek educational and training opportunities to improve knowledge, skills, and performance.	X
2.	Utilize clinical practice guidelines, appropriate use criteria, and other information tools at the point of care to improve clinical decision-making.	X
3.	Skill to conduct literature searches, abstract and interpret data, and apply results to clinical care.	X
4.	Solicit and incorporate feedback from patients, colleagues, and other healthcare team members to improve clinical performance.	X
5.	Use hospital and registry data to assess appropriateness, quality, and safety of cardiovascular care.	X
6.	Develop the practice of lifelong learning, including regular review of journals and practice guidelines/appropriate use criteria/consensus statements, and attendance at scientific and continuing medical education meetings.	X
<i>Evaluation Tools:</i> conference presentation, direct observation, multisource evaluation, reflection and self-assessment		
Professionalism		All Specialists
1.	Demonstrate respect, consideration, and empathy for patients, families, and all members of the healthcare team.	X
2.	Understand the potential role of subconscious biases in clinical decision-making and interpersonal relationships.	X
3.	Practice within the scope of personal expertise, training, and technical skills.	X
4.	Seek and integrate advice from consultants in a timely manner.	X
5.	Know current evidence-based clinical practice guidelines, consensus statements, appropriate use criteria, and performance measures relevant to scope of practice.	X
6.	Identify, disclose, and manage relationships with industry and other entities to minimize bias and undue influence on clinical decision-making.	X
7.	Demonstrate high ethical standards in personal and professional conduct.	X
8.	Take responsibility and follow through on professional commitments and obligations in a timely fashion.	X
9.	Identify potential for impaired professional performance in oneself and colleagues and take action to mitigate.	X
10.	Attend to one's own health, well-being, and abilities in order to maximize personal and professional performance.	X
<i>Evaluation Tools:</i> conference presentation, direct observation, multisource evaluation, reflection and self-assessment		
Interpersonal and Communication Skills		All Specialists
1.	Communicate with patients and families in an effective, timely, and culturally competent manner.	X
2.	Engage patients in shared decision-making based upon balanced presentation of potential risks, benefits, and alternatives, factoring in patients' values and preferences.	X
3.	Review medical records, complete documentation, and communicate results of diagnostic findings and management strategies to patients and collaborating healthcare professionals in a timely manner.	X
4.	Lead and collaborate in interdisciplinary and cardiovascular care teams, treating all team members with respect.	X
5.	Compassionately discuss sensitive/difficult topics, including end-of-life care and care of critically ill patients.	X
6.	Provide emotional support to patients and families.	X
<i>Evaluation Tools:</i> direct observation and multisource evaluation		

manifestations are related to arterial stenosis secondary to atherosclerosis. The trainee should also be knowledgeable in other less common conditions such as fibromuscular dysplasia, renal and visceral artery aneurysms, dissection, vasculitis, and median arcuate ligament

compression. Core training requirements also include knowing the indications and limitations for the imaging modalities to diagnose these disorders (ie, duplex ultrasound, CT angiography, MR angiography, and catheter-based angiography).

For patients with atherosclerotic renal artery disease and fibromuscular dysplasia, trainees should know the role of the renin-angiotensin-aldosterone axis in diagnosing and treating hypertension. They should also understand acute and chronic kidney disease states in these patients, as well as be cognizant of the presence of heart failure in patients with bilateral renal artery stenosis. The trainee must be familiar with optimal medical therapy for the management of patients with renal artery disease, as well as indications, risks and benefits of revascularization strategies. The trainee must also be familiar with the management of patients with mesenteric artery disease, including the risks and benefits of revascularization strategies. Trainees should know how to manage renal and visceral artery aneurysms and indications for referral for repair.

#### **4.2.3. Cerebrovascular Disease**

Vascular medicine trainees must acquire the medical knowledge and clinical skills to diagnose and manage patients with extracranial cerebrovascular disease, including atherosclerotic and nonatherosclerotic diseases (such as fibromuscular dysplasia and carotid artery dissection). Core training requirements also include knowing the indications and limitations for the imaging modalities to diagnose cerebrovascular disease (ie, duplex ultrasound, CT angiography, MR angiography, and catheter-based angiography).

For patients with atherosclerotic cerebrovascular disease, trainees should define and apply appropriate risk stratification and medical therapies to reduce risk of stroke, including managing the most common risk factors for development and progression of cerebrovascular disease (eg, smoking, diabetes, hypertension, hypercholesterolemia). Trainees should also have a clear understanding of both the indications and risks associated with anticoagulation in patients with atrial fibrillation. Similarly, trainees should know the role of antiplatelet agents in prevention of stroke in patients with cerebrovascular disease.

Trainees should know the indications for intervention of carotid, vertebral, and subclavian artery stenosis. They should have broad exposure to the various surgical, endovascular, and hybrid interventions for management of cerebrovascular disease in order to recommend the optimal therapeutic strategy for patients in coordination with the care team.

Trainees should be capable of identifying early post-procedural complications (eg, stroke, hyperperfusion syndrome, cranial nerve injury) and the approach to management. They should be familiar with methods and intervals for long-term surveillance both prior to and after intervention.

#### **4.2.4. Aortic Diseases**

Vascular medicine trainees will need to know the pathophysiology of a wide breadth of aortic diseases,

including—but not limited to—acute aortic syndromes, aortic occlusive disease, aortic aneurysms. They should be knowledgeable about disorders associated with aortic aneurysm and dissection, such as inherited connective tissue disorders, familial thoracic aortic aneurysm syndromes, hypertension, bicuspid aortic valve, Turner's syndrome, atherosclerosis, vasculitis, and infections. They should know the clinical signs and symptoms in patients presenting with high-risk aortic diseases such as aortic dissection, intramural hematoma, penetrating atherosclerotic ulcer, and thoracic and abdominal aneurysms. The ability to evaluate and medically manage acute aortic syndromes is necessary for competency. In addition, trainees will be expected to know the strategies necessary for the long-term follow-up of patients with prior acute aortic syndromes. Trainees should be knowledgeable regarding indications, accuracy, and techniques of screening for thoracic, abdominal, and peripheral arterial aneurysms. Once a diagnosis of acute or chronic aortic disease has been made, knowledge of the indications and risks of both surgical and endovascular treatment with expected outcomes are essential to provide appropriate care. Similarly, indications for surgical and endovascular repair of both aortic and peripheral aneurysms will be important for trainees. Trainees should be skilled at the longitudinal evaluation of patients who have undergone aortic aneurysm open and endovascular repair. When the diagnosis of aortic aneurysm is confirmed, trainees should be able to provide counseling and education to patients and their families on the importance of genetic predisposition and screening methods.

#### **4.2.5. Vasculitis, Vasospastic, and Temperature-Related Disorders**

Vascular medicine trainees should learn when to consider vasculitis in the differential diagnosis of vascular disease and appropriately evaluate and diagnose small, medium, and large vessel vasculitis. Trainees should learn strategies for the medical management of vasculitis, including surveillance imaging, pharmacotherapy, and appropriate referral to or comanagement with rheumatology during the course of training. In addition, trainees should know when to refer patients for noninvasive and invasive diagnostic testing and revascularization. Similarly, trainees should acquire the knowledge and skills to diagnose, evaluate, and treat thromboangiitis obliterans; atheroembolism; erythromelalgia; and temperature-related disorders, including primary and secondary Raynaud phenomenon, acrocyanosis, erythema ab igne, and pernio.

#### **4.2.6. Acute and Chronic Venous Diseases**

##### **4.2.6.1. Acute Venous Disease**

Vascular medicine trainees should know the clinical epidemiology, pathophysiology, causes, and consequences of superficial and deep venous thrombosis and pulmonary embolism. Trainees should be familiar with the application of preventive strategies to reduce the incidence

of venous thromboembolism and know the symptoms and signs of superficial and deep venous thrombosis, pulmonary embolism, and the clinical risk stratification of patients with suspected venous thrombosis. Trainees should know appropriate use of biomarkers and imaging testing to diagnose venous thrombosis and pulmonary embolism and the acute management of venous thromboembolism, including clinical risk stratification and initial treatment regimens. They should know the appropriate indications and laboratory tests to assess for inherited and acquired thrombophilia. Trainees should also know the classes of anticoagulant medications and dosing regimens, as well as the benefits, risks, and complications of anticoagulant therapy, including those specific to each class of drugs. They should know the diagnostic and management strategies relevant to specific patient populations, such as pregnant women, patients with cancer, patients with severe obesity, and patients with chronic kidney disease. Trainees should be familiar with reversal agents used in the treatment of bleeding complications and know the indications and complications of inferior vena cava filters. Trainees should be familiar with advanced therapies, including the use of thrombolytic agents, and know the indications, contraindications, benefits, and risks for systemic and catheter-based thrombolysis, and catheter-based and surgical thrombectomy. Vascular medicine trainees must be knowledgeable about the causes, clinical presentation, and management of venous thrombosis of other anatomic locations, including inferior vena cava thrombosis, renal vein thrombosis, mesenteric venous thrombosis, portal vein thrombosis, and cerebral vein thrombosis.

#### 4.2.6.2. Chronic Venous Disease

Vascular medicine trainees should be familiar with the evaluation of chronic venous disease which comprises etiologies of post-thrombotic syndrome after initial or recurrent deep venous thrombosis; superficial venous disease; incompetent superficial, deep, or perforator disease; and compressive syndromes including iliac venous compression (May-Thurner syndrome) and venous thoracic outlet compression (Paget-Schroetter syndrome). Trainees should recognize the clinical symptoms of chronic venous disease such as pain, swelling, pruritus, and bleeding as well as the signs of chronic venous disease, including edema, varicose veins, skin changes of eczema, lipodermatosclerosis, corona phlebectatica, phlebolymphe­dema, and venous ulceration. Trainees should be able to classify severity using common scales such as the Venous Clinical Severity Scale (VCSS) and Clinical, Etiology, Anatomic, Pathophysiologic (CEAP) classification. Trainees should also be able to incorporate appropriate diagnostic tests, including duplex ultrasound to evaluate for obstruction and reflux, and MR and CT venograms to evaluate for obstruction or compressive syndromes. In addition, trainees should be familiar with

the use of plethysmography to discern venous outflow obstruction and learn to manage patients with chronic venous disease using compression therapy—multilayer and short stretch bandaging, inelastic garments, graded compression stockings, and pneumatic pumps. Trainees should know the indications for the use of topical anti-inflammatory steroid medications as well as antibiotic and diuretic therapy. Trainees should be able to identify patients who would benefit from interventional endovascular therapies to address chronic venous obstruction and venous compression syndromes and know the signs and symptoms of pelvic congestion syndrome and indications to refer for further evaluation. Trainees should also be familiar with referral criteria for superficial venous ablation and the techniques available, including thermal ablation (radiofrequency and laser), ambulatory phlebectomy, and chemical ablation.

#### 4.2.7. Lymphatic Diseases and Lipedema

Vascular medicine trainees should know the pathophysiology of lymphedema and be able to identify patients at risk. Trainees should be able to establish a differential diagnosis of lymphedema, including lipedema, myxedema, venous insufficiency, and systemic diseases that cause leg swelling; develop clinical judgement to refer for the most appropriate diagnostic tests; and interpret the results. Trainees should be able to diagnose causes of primary and secondary lymphedema and identify lymphedema when associated with an underlying medical syndrome (eg, Turner syndrome, Noonan syndrome). They should be familiar with genetic variants associated with lymphedema and know when to refer for genetic evaluation and counseling. Using clinical examination and testing when appropriate, the trainee should be able to distinguish between lymphedema and lipedema and determine a management plan. When the diagnosis of lymphedema is confirmed, trainees should be able to provide counseling and education to the patient and family on the importance of compression and decongestive therapy, prevention and prompt treatment of infections, and skin care. They should be able to initiate compression therapy, refer to a physical therapist specialized in manual lymphatic therapy and multimodal lymphedema therapy, and determine if a patient would benefit from advanced therapies such as compression pumps or referral for surgery.

#### 4.2.8. Noninvasive Diagnostic Tests

Expert knowledge of noninvasive vascular diagnostic testing is a distinguishing feature of the Level III-trained vascular medicine specialist. The curriculum should include diagnostic testing procedures and equipment, appropriate indications, diagnostic criteria, and technical limitations. In addition to the curricular components, Level III trainees should have extensive mentored experience in interpreting vascular studies and have had significant hands-on exposure in vascular testing. The

Physicians' Vascular Interpretation Examination should be successfully completed after either Level II or III training. Interpretation under faculty supervision of at least 500 studies distributed across the vascular testing areas is a prerequisite for the Registered Physicians Vascular Interpretation Examination.<sup>8</sup> The primary testing areas are duplex ultrasonography of the veins, extremity arteries (including bypass grafts and stents), extracranial (ie, carotid) and intracranial (ie, transcranial Doppler) arteries, the renal and mesenteric arteries, and the abdominal aorta as well as multilevel physiological testing of the extremities at rest and with exercise. As discussed in Section 3.3, it is acknowledged that some trainees who have completed Level II training in vascular medicine prior to the advanced training program will have already obtained adequate experience to qualify for the RPVI examination. For such individuals, and all Level III trainees, additional time spent in the vascular laboratory during the training program should focus on acquisition of hands-on scanning skills (Section 3.3) as well as skills to interpret and perform ultrasound assessment and treatment of post-catheterization access site complications (ie, pseudoaneurysm, arteriovenous fistula). Additional training is necessary to perform and interpret transcranial Doppler tests for assessment of intracranial arteries and perform and analyze vascular tests used for research (eg, carotid intimal-medial thickness, brachial reactivity, arterial stiffness assessment). For Level III trainees with future interest in serving as Medical Director of a noninvasive vascular laboratory, additional didactic topics and experience should include: principles of appropriateness of vascular testing, developing a quality-improvement program, including processes for peer review and cross-modality correlative imaging study, vascular laboratory accreditation, and operational aspects of the vascular laboratory, including equipment utilization and maintenance. As training in the vascular laboratory is a central component of advanced training in vascular medicine, it is important that comprehensive facilities and dedicated equipment are available and that laboratories are accredited by the Intersocietal Accreditation Commission Vascular Testing Division.<sup>11</sup> Faculty members, including allied health professionals, should have extensive experience in noninvasive vascular testing, including certification of physician faculty and technologists/sonographers by the RPVI, RVT, or equivalent discipline-appropriate credential.

## 5. LEADERSHIP AND ADMINISTRATIVE COMPETENCIES

In addition to clinical competency, Level III-trained vascular specialists are expected to function effectively as leaders in allied efforts to ensure high-quality care and promote individual and population health. Some of these activities and attributes fall outside the realm of clinical

knowledge and skill and instead involve administrative roles in clinical practice, hospitals, health systems, professional societies, or other organizations. Developing a familiarity with accreditation standards for vascular laboratories and participation in an accreditation process are examples of how an advanced vascular medicine fellow can gain experience in laboratory administration.<sup>11</sup> The intention of training is to provide a foundation of leadership and administrative skills that would be enhanced and refined throughout one's career after fellowship. Specific competencies expected of all general cardiologists and cardiovascular specialists, including those whose careers involve greater involvement in administrative, managerial, or advocacy positions, are delineated in Table 18 of the 2016 ACC Lifelong Learning Competencies for General Cardiologists.<sup>2</sup>

## 6. EVALUATION OF PROFICIENCY

Evaluation of a trainee's proficiency in advanced training in vascular medicine involves multiple assessments of the trainee's ability to function as a specialist to clinically diagnose and manage patients across the broad range of vascular disease; apply clinical and laboratory information; and plan, perform, and accurately interpret vascular diagnostic studies. These assessments include multisource evaluation, direct observation by instructors, case logs, chart review (including adherence to utilization guidelines, appropriate use criteria, and patient outcomes), simulation training, the trainee's portfolio (including scholarly productivity and quality improvement projects), and assessment of leadership skills. The trainee's organization of, and participation in, didactic conferences and case presentations also provides opportunities to evaluate the trainee's proficiency. Trainees have access to self-assessment programs through the ACC and the SVM.

Each trainee must be evaluated regularly regarding clinical judgment, case management, and procedural skills. This includes consideration of judgments or actions that may result in complications; quality of care and follow-up management; interactive behaviors with patients and their families and other members of the health care team; and ability to independently make appropriate decisions. Trainees must maintain records of participation and advancement using an electronic database or procedure logbook that is Health Insurance Portability and Accountability Act (HIPAA) compliant and contains pertinent clinical information, including number of cases, diagnoses (including comparison of vascular study interpretation with other available vascular diagnostic modalities), disease severity, outcomes, and disposition.

The vascular medicine training program director is responsible for confirming trainee experience and competence, working with faculty instructors to verify

and document trainee performance, and reviewing the overall progress of trainees to ensure achievement of training milestones and identification of areas in which additional focused training may be required. On a periodic basis, the program director should review each trainee's case logbook to ensure adequacy of exposure to a broad spectrum of pathology and experience in acquiring and interpreting diagnostic vascular studies.

Following the completion of advanced training in vascular medicine, trainees are expected to take the certification examination in vascular medicine offered by the American Board of Vascular Medicine (ABVM). Information concerning eligibility and prerequisites for this certification can be obtained from ABVM.<sup>12</sup> Additionally, trainees are expected to have completed certification for interpreting noninvasive vascular examinations such as the Registered Physician in Vascular Interpretation (RPVI) credential offered by the Alliance for Physician Certification and Advancement (APCA).<sup>8</sup> For trainees who have completed supplemental training in performance of vascular studies during their fellowship, the American Registry for Diagnostic Medical Sonography (ARDMS) provides additional certification with the Registered Vascular Technologist (RVT) credential offered by the ARDMS.<sup>13</sup> Information concerning eligibility and prerequisites for these certifications can be obtained from APCA and ARDMS.

## ACC COMPETENCY MANAGEMENT COMMITTEE

James A. Arrighi, MD, FACC, Chair; Lisa A. Mendes, MD, FACC, Co-Chair; Jennifer Day, MSN, RN; G. William Dec Jr, MD, FACC; Ali Denktas, MD, FACC; David Drajpuch, ACNP-BC, CRNP, FNP-BC, MSN; Susan Fernandes, LPD, PA-C\*; Sanjeev A. Francis, MD, FACC; Rebecca T. Hahn, MD, FACC; Susan D. Housholder-Hughes, DNP, ACNS-BC, ANP-BC, FACC; Sadiya S. Khan, MD, FACC; Kyle Klarich, MD, FACC\*; Meera Devi Kondapaneni, MBBS, FACC; Kwan S. Lee, MD, FACC; C. Huie Lin, MD, PhD, FACC; Joseph E. Marine, MD, FACC\*; Shannon McConnaughey, MD, FACC; Khusrow Niazi, MBBS, FACC; Thomas Ryan, MD, FACC; Frank E. Silvestry, MD, FACC; Michael A. Solomon, MD, MBA, FACC; Robert L. Spicer, MD, FACC; Andrew Wang, MD, FACC, FAHA\*;

\*Former Competency Management Committee member; member during this writing effort.

Gaby Weissman, MD, FACC; Howard H. Weitz, MD, MACP, FACC\*

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## ARTICLE INFORMATION

This document was approved by the American College of Cardiology Lifelong Learning Oversight Committee, the American Heart Association Science Advisory and Coordinating Committee and Executive Committee, the Society for Vascular Medicine Board of Directors, and the American College of Physicians Board of Regents in August 2020 and endorsed by the Association of Black Cardiologists, Society for Cardiovascular Angiography and Interventions, Society for Vascular Nursing, and the Society for Vascular Surgery in September 2020.

For the purpose of transparency, disclosure information for the Lifelong Learning Oversight Committee, the approval body of the convening organization of this document, is available at <https://www.acc.org/guidelines/about-guidelines-and-clinical-documents/clinical-document-approval>.

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The expert peer review of AHA-commissioned documents (eg, scientific statements, clinical practice guidelines, systematic reviews) is conducted by the AHA Office of Science Operations. For more on AHA statements and guidelines development, visit <https://professional.heart.org/statements>. Select the "Guidelines & Statements" drop-down menu near the top of the webpage, then click "Publication Development."



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**Appendix 1. Author Relationships With Industry and Other Entities (Relevant)–2021 ACC/AHA/SVM/ACP Advanced Training Statement on Vascular Medicine**

Committee Member	Employment	Consultant	Speakers Bureau	Ownership/ Partnership/ Principal	Personal Research	Institutional/ Organizational or Other Financial Benefit	Expert Witness
Mark A. Creager, Chair	Dartmouth-Hitchcock Medical Center—Director, Heart and Vascular Center	None	None	None	None	None	None
Naomi M. Hamburg, Vice Chair	Boston University School of Medicine—Associate Professor of Medicine, Cardiovascular Medicine Section	<ul style="list-style-type: none"> <li>Amgen</li> <li>Bayer</li> <li>Merck</li> <li>Sanifit</li> </ul>	None	None	None	None	None
Keith D. Calligaro	Pennsylvania Hospital—Chief, Vascular Surgery; Director Vascular Surgery Fellowship; Clinical Professor of Surgery	None	None	None	None	None	None
Ana I. Casanegra	Mayo Clinic Gonda Vascular Center—Director of the Thrombosis and Thrombophilia Clinic; Mayo Clinic, Cardiovascular Department, Vascular Medicine Division—Associate Professor of Medicine	None	None	None	None	None	None
Rosario Freeman	University of Washington—Professor of Medicine; Program Director, Cardiology Fellowship	None	None	None	None	None	None
Phyllis A. Gordon	University of Texas Health Science Center at San Antonio—Vascular Surgery Division Assistant Clinical Professor (Retired)	None	None	None	None	None	None
Heather L. Gornik	University Hospitals Harrington Heart and Vascular Institute—Co-Director, Vascular Center; Case Western Reserve University School of Medicine—Professor of Medicine	None	None	<ul style="list-style-type: none"> <li>Flexlife Health*</li> </ul>	None	<ul style="list-style-type: none"> <li>Intersocietal Accreditation Commission—Vascular Testing Division†</li> </ul>	None
Esther S.H. Kim	Vanderbilt Heart and Vascular Institute—Associate Professor of Medicine Cardiovascular Medicine Section of Vascular Medicine	None	None	None	None	<ul style="list-style-type: none"> <li>Acer Therapeutics</li> </ul>	None
Nicholas J. Leeper	Stanford University School of Medicine—Chief of Vascular Medicine, Director of Vascular Research, Professor of Surgery and Medicine	<ul style="list-style-type: none"> <li>Janssen Pharmaceuticals*</li> <li>Sanofi</li> </ul>	None	None	None	None	None

(Continued)

## Appendix 1. Continued

Committee Member	Employment	Consultant	Speakers Bureau	Ownership/ Partnership/ Principal	Personal Research	Institutional/ Organizational or Other Financial Benefit	Expert Witness
Geno J. Merli	Thomas Jefferson University Hospital—Sr. Vice President, Associate CMO; Jefferson Vascular Center—Co-Director; Sidney Medical College—Professor of Medicine and Surgery, Division of Vascular Medicine	None	None	None	None	None	None
Khusrow Niazi	Emory University—Director, Peripheral Vascular Intervention	None	• Medtronic	None	• Surmodics* • Tririme*	None	None
Jeffrey W. Olin	Zena and Michael A. Wiener Cardiovascular Institute and Marie-Josée and Henry R. Kravis Center for Cardiovascular Health Icahn School of Medicine at Mount Sinai—Professor of Medicine (Cardiology); Director, Vascular Medicine and Vascular Diagnostic Laboratory	• Janssen Pharmaceuticals	None	None	None	None	None
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Christopher J. White	Ochsner Medical Center—Professor and Chairman of Medicine and Cardiology; Medical Director Value Based Care System Chair for Cardiovascular Diseases	None	None	None	None	None	None
Khendi White Solaru	University Hospitals Harrington Heart and Vascular Institute—Assistant Professor, Department of Medicine; Case Western Reserve University School of Medicine Department of Cardiovascular Medicine—Staff Physician	None	None	None	None	None	None
Marlene S. Williams	The Johns Hopkins University—Associate Professor of Medicine; Johns Hopkins Bayview Medical Center—Cardiac Intensive Care Unit Director	• Haemonetics	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  $\geq \$5000$  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 <https://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, 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.

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†No financial benefit.

ACC indicates American College of Cardiology; ACP, American College of Physicians; AHA, American Heart Association; BMS, Bristol-Myers Squibb; CMO, Chief Medical Officer; and SVM, Society for Vascular Medicine.

**Appendix 2. Peer Reviewer Information—2021 ACC/AHA/SVM/ACP Advanced Training Statement on Vascular Medicine**

Name	Employment	Representation in Peer Review Process
Geoffrey D. Barnes	University of Michigan—Assistant Professor of Internal Medicine	Official Reviewer, SVM
Joshua A. Beckman	Vanderbilt University Medical Center—Director, Vascular Medicine Section; Professor of Medicine	Official Reviewer, SVM
Umberto Campia	Brigham and Women's Hospital—Associate Physician	Official Reviewer, AHA
Douglas E. Drachman	Massachusetts General Hospital—Heart Center Director of Education	Official Reviewer, ACC Lifelong Learning Oversight Committee
Natalie S. Evans	Case Western Reserve University School of Medicine—Clinical Assistant Professor	Official Reviewer, AHA
Sanjeev A. Francis	Maine Medical Center MaineHealth Cardiology—Director of Education, Cardiovascular Institute Director, Cardiovascular Medicine Fellowship Program; Tufts University School of Medicine—Assistant Professor of Medicine	Official Reviewer, Competency Management Committee Lead Reviewer
Sanjay Gandhi	MetroHealth Hospital—Medical Director of Hospital Strategy and Innovation; Case Western University—Associate Professor of Medicine	Official Reviewer, ACC Board of Governors
James Kumar	Carle Foundation Hospital, University of Illinois—Clinical Associate Professor, Director, Carle Internal Medicine Residency Program	Official Reviewer, ACP
Aruna Pradhan	Brigham and Women's Hospital—Associate Physician; Harvard Medical School—Associate Professor of Medicine	Official Reviewer, AHA
Eric A. Secemsky	Beth Israel Deaconess Medical Center—Director of Vascular Intervention; Harvard Medical School—Assistant Professor of Medicine	Official Reviewer, SVM
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Jasmiry Bennett	Baylor Heart and Vascular Hospital—Advance Practice Professional Manager	Organizational Reviewer, SVN
John M. Fontaine	Drexel University College of Medicine—Professor of Medicine	Organizational Reviewer, ABC
Peter Henke	University of Michigan—Professor of Surgery	Organizational Reviewer, SVS
Uzoma N. Ibebuogu	University of Tennessee Health Science Center—Associate Professor of Medicine, Cardiology; Associate Professor of Preventive Medicine	Organizational Reviewer, ABC
Sasanka Jayasuriya	Ascension Columbia St. Mary's Hospital—Director Cardiac Catheterization Laboratories	Organizational Reviewer, SCAI
Ashley Moore	Texas Vascular Associates—Adult-Gerontology Acute Care Nurse Practitioner	Organizational Reviewer, SVN
Thomas F. Rehring	Colorado Permanente Medical Group—Chief, Vascular and Endovascular Surgery	Organizational Reviewer, SVS
Subhash Banerjee	University of Texas Southwestern Medical Center—Professor of Medicine; VA North Texas Health Care System—Chief, Division of Cardiology and Director Cardiac Catheterization Laboratory	Content Reviewer, ACC Peripheral Vascular Disease Section Leadership Council
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Lawrence A. Garcia	Steward St. Elizabeth's Medical Center—Chief, Interventional Cardiology and Vascular Interventions	Content Reviewer, ACC Peripheral Vascular Disease Section Leadership Council
Bruce H. Gray	Prisma Health System, Greenville Memorial Hospital—Vascular Medicine Specialist; University of South Carolina School of Medicine—Professor of Surgery and Vascular Medicine	Content Reviewer, COCATS 4 Task Force 9 Writing Committee Member
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(Continued)

**Appendix 2. Continued**

Name	Employment	Representation in Peer Review Process
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Susan D. Housholder-Hughes	University of Michigan—Nurse Practitioner, Adjunct Clinical Faculty, School of Nursing	Content Reviewer, Competency Management Committee
Richard A. Josephson	Case Western Reserve University—Professor of Medicine; Harrington Heart & Vascular Institute, University Hospitals—Director of Cardiovascular and Pulmonary Rehabilitation	Content Reviewer, Prevention of Cardiovascular Disease Section Leadership Council
Scott Kinlay	VA Boston Healthcare System—Associate Chief Cardiology and Director of Vascular Medicine	Content Reviewer, Peripheral Vascular Disease Section Leadership Council
Viet T. Le	Intermountain Heart Institute, Intermountain Healthcare and Rocky Mountain University of Health Professions Physician Assistant Program—Cardiology Research Physician Assistant	Content Reviewer, ACC CV Team Section Leadership Council
Radmila Lyubarova	Albany Medical Center—Associate Professor of Medicine Division of Cardiology	Content Reviewer, ACC Geriatric Section Leadership Council
Carlos Mena	Yale New Haven Hospital—Director, Cardiac Catheterization Laboratories and Director, Vascular Medicine Fellowship; Yale University—Associate Professor of Medicine, Cardiology	Content Reviewer, ACC Peripheral Vascular Disease Section Leadership Council
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Michael N. Young	Dartmouth-Hitchcock Medical Center—Interventional Cardiology; Geisel School of Medicine at Dartmouth—Assistant Professor of Medicine	Content Reviewer, ACC Interventional Section Leadership Council
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This table represent the individuals, organizations, and groups that peer reviewed this document. A comprehensive list of healthcare-related disclosures for each reviewer can be found in [Supplemental Appendix II](#).

ABC indicates Association of Black Cardiologists; ACC, American College of Cardiology; ACP, American College of Physicians; AHA, American Heart Association; COCATS, Core Cardiovascular Training Statement; CV, cardiovascular; SCAI, Society for Cardiovascular Angiography and Interventions; SVM, Society for Vascular Medicine; SVN, Society for Vascular Nursing; SVS, Society for Vascular Surgery; and VA, Veterans Affairs.

**Appendix 3. Abbreviations**

ACGME	Accreditation Council for Graduate Medical Education
COCATS	Core Cardiovascular Training Statement
RWI	relationship with industry
PAD	peripheral artery disease