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Cardiovascular physicians frequently encounter vascular diseases. Atherosclerosis and thrombosis, in particular, are systemic disorders with clinical manifestations in most peripheral circulations. These and other vascular diseases account for substantial cardiovascular morbidity and mortality. Moreover, technological advances in imaging techniques and catheter-based interventions have brought management of vascular diseases firmly into the sphere of the cardiovascular specialist. Training in vascular medicine should be incorporated in a cardiovascular fellowship in order to accommodate the clinical demands of this contemporary paradigm. Accordingly, 3 levels of training in vascular medicine are described.

**Level 1**—Basic training in vascular medicine that all fellows should receive to acquire a sufficient knowledge base to care for many patients with vascular disease.

**Level 2**—Additional training for fellows who wish to develop special expertise in evaluating and managing patients with vascular disease. This level does not include training in catheter-based interventions.

**Level 3**—Training for noncoronary peripheral vascular catheter-based vascular interventions. This level of training is to ensure that the fellow develops both the cognitive and technical skills requisite to making appropriate decisions regarding invasive and interventional treatment of patients with vascular disease.

LEVEL 1: BASIC TRAINING FOR ALL CARDIOVASCULAR FELLOWS

The essentials of vascular medicine should be taught to all fellows. Vascular medicine training should be integrated into the fellowship program and include the evaluation and management of vascular diseases, exposure to noninvasive diagnostic modalities, angiography, and peripheral catheter-based interventions. The equivalent of at least 2 months of the fellowship, either as dedicated rotations or in the aggregate as an integral component of other rotations, should be devoted to vascular medicine. Acquisition of this fundamental knowledge will permit the fellow to recognize a broad array of vascular diseases and common medical disorders associated with vascular disease, to initiate appropriate medical management, and to appropriately refer patients to a vascular specialist when necessary for further evaluation and intervention. This level of training, however, is not sufficient to qualify the trainee as a vascular specialist capable of managing complex vascular patients.

Components of Training

The fellow should receive training in the evaluation and management of arterial, venous, and lymphatic diseases, such as peripheral arterial disease, acute arterial occlusion, carotid artery disease, renal artery stenosis, aortic aneurysm, vasculitis, vasospasm, venous thrombosis and insufficiency, and lymphedema (Table I). Training should also include instruction in the recognition and management of medical disorders associated with vascular diseases, including hypertension, hypercholesterolemia, diabetes mellitus, and hypercoagulable states. Fellows should also be trained to perform a comprehensive pre-operative evaluation of the patient undergoing vascular surgery, to be cognizant of the indications and risks of pre-operative testing, and to

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Trainees should receive instruction in the noninvasive vascular laboratory and know the indications for vascular tests, such as segmental pressure measurements, pulse-volume recordings, and duplex ultrasonography, as well as the information that can be derived from such testing. Furthermore, the fellow should understand the imaging techniques that can be used to further assess the aorta, vena cavae, and peripheral arteries and veins, such as computed tomography angiography (CTA) and magnetic resonance angiography (MRA), and recognize the indications for catheter-based interventions and surgical revascularization.

All cardiovascular medicine fellowship candidates should participate in noncardiac peripheral angiography (i.e., aortography; angiography of first-order branch vessels of the aorta, such as the iliac, renal, or subclavian arteries; and second-order branch vessels, such as the internal mammary arteries; and pulmonary angiography) in patients with whom they are involved from pre-catheterization clinical evaluation to final disposition. This training will not qualify the trainee to independently perform peripheral angiography.

**Structure of the Level 1 Training Program**

**Faculty**

In a few institutions, leadership for the vascular medicine component of the training program will come from vascular medicine specialists. In many programs, however, the exposure to vascular medicine will come from faculty in other disciplines, such as cardiology, hematology, neurology, vascular surgery, and vascular radiology. All faculty responsible for training fellows in vascular medicine should be board certified or board eligible and recognized as experts in their subspecialties.

**Facilities**

The principal training institution should have facilities to care for patients with vascular disease that include a noninvasive vascular laboratory accredited.
by the Intersocietal Commission for the Accreditation of Vascular Laboratories (ICAVL), a peripheral vascular catheterization laboratory, a comprehensive vascular surgery program, and offices for outpatient evaluation and treatment.

**Content of Conferences**

Conferences should incorporate case presentations and formal lectures that review current diagnostic and therapeutic approaches to arterial, venous, and lymphatic disease. Case presentations should illustrate the use of clinical tools, noninvasive laboratory testing, and angiography. Conferences should provide the trainee with information regarding the natural history of peripheral vascular disorders, the long-term risks and benefits of peripheral intervention, and noninterventional approaches to vascular disease. Formal lectures on the pathobiology of vascular diseases, including atherosclerosis, restenosis, and thrombosis, should be incorporated.

**Trainee Evaluation**

The fund of knowledge regarding vascular disease must be evaluated in every trainee. Quality of clinical skills; reliability; judgments or actions that result in patient complications; and interaction with other physicians, patients, and laboratory support staff are key components of the evaluation. Initiative and ability to make independent and appropriate decisions are to be considered. The program director has the responsibility to confirm or deny the experience and competence of trainees.

**LEVEL 2: REQUIREMENTS FOR TRAINING FELLOWS WISHING TO PURSUE A CAREER IN VASCULAR MEDICINE**

Fellows planning a career in vascular medicine require a distinct and comprehensive training program. In addition to the 24 months required for board eligibility in cardiovascular medicine, another 12 months of training, typically during a third or fourth year, should provide a curriculum to enable the fellow to become an expert in vascular medicine (1,2). The prerequisite for Level 2 training is Level 1 training in vascular medicine. The fellow who wishes to be trained in peripheral vascular intervention will require additional training as outlined in later text (see Level 3).

**Components of Training**

Trainees who plan a vascular medicine track as part of their cardiovascular fellowship should spend at least 2 to 3 months on an inpatient vascular medicine consultation service; 3 months in the noninvasive vascular laboratory; 1 to 2 months learning MRA and CTA; and 1 to 2 months in the peripheral vascular catheterization laboratory (Table I). In addition, at least one-half to 1 day per week throughout the year should be spent in the outpatient vascular medicine clinic. In addition, there should be sufficient exposure to the diagnosis and treatment of peripheral arterial disease, aortic diseases, cerebrovascular disease, renal artery stenosis, venous thromboembolic diseases, chronic venous disorders, lymphatic diseases, vasculitides, atheromatous embolization, vasospastic disease, and chronic venous insufficiency, as well as other uncommon vascular diseases.

The time spent on the inpatient hospital service and outpatient clinic should include experience with risk factor modification, including smoking cessation interventions and treatment of dyslipidemia, hypertension, and thrombophilic disorders, because these are important components of many vascular diseases. Additional rotations could be allocated to vascular surgery, hematology, neurology, and rheumatology to acquire fundamental experience in these important areas as they relate to vascular medicine.

Expertise in the noninvasive vascular laboratory is one of the most important aspects of training for the vascular medicine specialist. Although the principles of ultrasound are the same whether one is performing an echocardiogram or a vascular ultrasound, there are many important differences in technique and interpretation that require special training. The trainee should understand the principles of ultrasound physics, Doppler characteristics, and transducer technology. The fellow should perform and interpret the following vascular studies under supervision: 1) duplex ultrasonography of the veins and arteries of the upper and lower extremities; 2) the aorta; 3) the renal and mesenteric arteries and veins; 4) the carotid arteries; 5) infragenual bypass grafts; and 6) physiologic tests of peripheral arteries and veins, among others. The number of noninvasive vascular laboratory procedures required for each of the studies performed in the vascular laboratory should follow the guidelines recommended by the ICAVL (3). These include, but are not limited to, 100 venous, 100 peripheral artery (including bypass grafts), 100 carotid artery, and 75 visceral artery and venous (renal and mesenteric) duplex ultrasound studies, as well as 100 physiologic arterial examinations.

In addition, dedicated time should be spent learning the basic principles of MRA and CTA. The trainees should acquire the cognitive and clinical skills necessary to review the MRA and CTA of peripheral ves-
sels, including the aorta, and brachiocephalic, limb, renal, and mesenteric arteries when evaluating patients with vascular disease. This experience is not intended to qualify the trainee in the performance and formal interpretation of MRA or CTA. Expertise in MRA and CTA will require additional time to acquire the comprehensive skills needed to perform and independently interpret these imaging modalities (see the Task Force 12 and 13 reports).

During the period of training in the catheterization laboratory, the fellow should learn the fundamentals of angiography and peripheral catheter-based interventions. The trainee should participate in peripheral diagnostic angiograms and peripheral interventions, including angioplasty, stent implantation, and thrombolysis. Training should emphasize interpretation of angiograms and permit the fellow to acquire an understanding of the indications and potential outcomes of invasive diagnostic procedures and catheter-based treatments. This experience is not intended to qualify the trainee as an interventionalist (see Level 3).

STRUCTURE OF THE LEVEL 2 TRAINING PROGRAM

Faculty

The trainee should be exposed to individuals who have special training in vascular medicine and cardiovascular diseases. Ideally, these faculty will be board certified in vascular medicine and/or endovascular medicine by the American Board of Vascular Medicine. It is recognized, however, that this may not be possible at all institutions. Therefore, the cardiovascular fellow may need to spend time in other departments or divisions to gain the necessary expertise to be a vascular medicine specialist. As per Level 1 training, all faculty responsible for training fellows in vascular medicine should be board certified or board eligible and recognized as experts in their subspecialties. Areas where this may be most important include the noninvasive vascular laboratory, angiography suite, vascular surgery, hematology, neurology, and rheumatology. The faculty should be required to provide didactic and practical education to the fellow, as well as appropriate feedback about the trainee’s performance.

Facilities

Adequate space should be available in the outpatient clinics to see patients. The noninvasive vascular laboratory should be accredited by the ICAVL and have equipment of suitable quality to perform all of the studies previously listed. There should be dedicated, fully equipped areas for magnetic resonance and computed tomographic imaging. A peripheral vascular catheterization laboratory equipped as stated in the following text should also be a requirement for the cardiovascular fellow’s training in vascular medicine. There should be an active and comprehensive vascular surgery program at the institution, and facilities for treatment of leg ulcers should be available.

Content of Conferences

The cardiovascular fellowship program should have a comprehensive conference series for topics of importance for the vascular medicine specialist. A conference dedicated to a core curriculum of topics should be scheduled throughout the year. Additional conferences could include angiography and imaging, vascular medicine grand rounds, a journal club, and morbidity and mortality.

Evaluation of Trainee and Faculty

As with every successful post-graduate training program, this program requires bi-directional evaluations. The faculty evaluates and provides positive and negative feedback to the trainee, and the trainee evaluates the faculty. Formal evaluations of the fellows and faculty should occur after each rotation. The program director should review these evaluations with the trainee and with the faculty individually. Mechanisms should be incorporated into the training program so that the fellow who performs suboptimally can be counseled and further action can be taken if necessary. The American Board of Vascular Medicine administers a certifying examination in vascular medicine. The fellow will be expected to take and pass this examination.

LEVEL 3: TRAINING FOR PERIPHERAL VASCULAR CATHETERIZATION AND INTERVENTION

Catheter-based peripheral angiography (arterial and venous) and interventional procedures are important components of a modern clinical cardiovascular practice. The trainee who plans to perform peripheral catheter-based angiography and interventions will be required to complete an additional period of training in these special procedures to obtain the basic fund of knowledge, technical skills, and the clinical judgment requisite for performing these invasive studies (1).

Components of Training

Trainees who plan to perform independent peripheral vascular catheterization (arteriography and venography) and interventions must become knowledgeable about normal vascular anatomy and common anatomic var-
The trainees should receive specific training in the techniques of vascular access from multiple sites (femoral, popliteal, and upper extremity arteries and veins). They should be trained to manipulate guidewires and catheters, place and deploy angioplasty equipment and devices, perform catheter-directed thrombolysis/thrombectomy, and obtain hemostasis via the application of compression and vascular closure devices. They should acquire the ability to perform vascular interventions in each of the following: aorta and lower extremity arteries, cervical arteries, brachiocephalic and upper extremity arteries, mesenteric and renal arteries, central and peripheral veins, and pulmonary arteries. Trainees must learn the indications, limitations, and complications of vascular interventional procedures, and understand the alternative treatments.

Level 3 training in peripheral angiography and catheter-based peripheral vascular intervention must also provide the fellow with the cognitive tools requisite to evaluating and managing patients with vascular disease. In some respects, this overlaps with Level 2 training. Trainees should spend the equivalent of 1 month on an inpatient vascular consultation service, 1 to 2 months dedicated to vascular imaging (including duplex ultrasonography, and MRA and CTA), and 1 half-day per week in an outpatient vascular clinic to acquire the knowledge necessary to manage patients with peripheral arterial disease, aortic diseases, renal artery stenosis, cerebrovascular disease, venous thrombosis, and other relevant vascular diseases (Table 1). The trainees should acquire the cognitive and clinical skills necessary to review duplex ultrasound studies of peripheral arteries and veins as well as the MRA and the CTA of peripheral vessels, including the aorta, and brachiocephalic, limb, renal, and mesenteric arteries when evaluating patients with vascular disease as described for Level 2 training. This experience is not intended to qualify the trainee in the performance and formal interpretation of vascular ultrasound studies, MRA, or CTA. Level 2 training is not a prerequisite for Level 3 training but is suggested for those wishing to acquire comprehensive training in vascular medicine in order to complement skills developed during Level 3 training.
required as a prerequisite (also see the Task Force 3 report). Requirements for Level 3 training in peripheral vascular intervention can be fulfilled during a fourth year of interventional training focused on peripheral vascular intervention or concurrently with cardiac interventional training.

For trainees planning to perform peripheral vascular interventional procedures, dedicated peripheral vascular interventional fellowship training is required, during which time the minimum requirements specified by the Clinical Competence Statement on Vascular Medicine and Catheter-Based Peripheral Vascular Interventions must be met (1). These requirements can be met during a fourth year of interventional training focused on peripheral vascular intervention or concurrently with cardiac interventional training. Current guidelines for competence indicate that trainees should perform at least 100 diagnostic angiograms, 50 peripheral angioplasties, and 10 peripheral thrombolytic/thrombectomy interventions.

Content of Conferences

All trainees must attend a regular cardiovascular catheterization and angiography conference. It is important that the cardiologist understand the complexities and limitations of the cardiovascular angiographic laboratory. Formal conferences should stress the relation of medical history, physical examination findings, hemodynamic findings, and angiographic findings for the selection of patients for therapy (i.e., medicine, surgery, or intervention). Interaction with the other vascular specialists at these conferences is important.

The trainee should be familiar with the rationale for patient selection for these diagnostic studies and should be required to attend conferences at least weekly for the duration of the catheterization/angiography rotation. Attendance at regular morbidity and mortality conferences is a requirement.

Trainee Evaluation

Case selection and procedural judgment, as well as interpretive and technical skills, must be evaluated in every trainee. This is particularly important for the trainee who eventually will work full time in a diagnostic cardiovascular angiography laboratory or perform catheter-based vascular interventional procedures. Quality of the clinical follow-up: reliability; judgments or actions that result in patient complications; interaction with other physicians, patients, and laboratory support staff; appropriate initiative; and the ability to make independent and appropriate decisions should be considered.

The competence of all cardiology trainees in cardiovascular angiography and intervention should be documented by both the program director and the director of the catheterization laboratory. The program director has the responsibility to confirm or deny the technical competence and catheterization laboratory exposure of trainees. The granting of hospital privileges remains within the purview of the individual institution.

Evaluation of the trainee who undertakes special training in catheter-based peripheral angiography and vascular intervention shall include the documentation (in the form of a logbook containing clinical information, procedure performed, and outcome of the procedure, including any complications experienced by the patient) of the performance of at least the minimum number of procedures set forth in the Clinical Competence Statement on Vascular Medicine and Catheter-Based Peripheral Vascular Interventions (1). Evaluation of the trainee for catheter-based peripheral vascular intervention shall include the documentation (in the form of a logbook) of the performance of at least the minimum number of procedures set forth in the Clinical Competence Statement (1).

This is an update of the 2002 document that was written by Mark A. Creager, MD, FACC—Chair; John P. Cooke, MD, PhD, FACC; Jeffrey W. Olin, DO, FACC (Society of Vascular Medicine and Biology Representative); and Christopher J. White, MD, FACC.

TASK FORCE 11 REFERENCES

### APPENDIX 1. AUTHOR RELATIONSHIPS WITH INDUSTRY—ACCF 2008 RECOMMENDATIONS FOR TRAINING IN ADULT CARDIOVASCULAR MEDICINE CORE CARDIOLOGY TRAINING (COCATS 3)—TASK FORCE 11: TRAINING IN VASCULAR MEDICINE AND PERIPHERAL VASCULAR CATHETER-BASED INTERVENTIONS

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