

The previous decade has seen explosive growth in technological advances in the endovascular arena. A partial list of these technologies would include carotid angioplasty and stenting, refinements in thoracic and abdominal endografts, and lower extremity angioplasty stenting, atherectomy, and mechanical thrombectomy. The field of vascular surgery has completely embraced these minimally invasive techniques and adapted its training paradigms accordingly. With the increasing complexity and breadth of endovascular interventions, vascular surgery has become a distinct surgery specialty. Reflecting this change, candidates for the Vascular Surgery Board examination of the American Board of Surgery (VSB-ABS) can sit for the examination after completion of an Accreditation Council for Graduate Medical Education (ACGME)-accredited vascular residency without previous certification in general surgery.

Vascular surgery is the specialty that deals with diagnosis and management of disorders of the arterial, venous, and lymphatic systems, exclusive of intracardiac and intracranial vessels [1]. A fully trained vascular surgeon should be a specialist who performs open surgery and endovascular interventions and has the expertise in vascular medicine to manage appropriate patients non-operatively. This expertise includes the skills to interpret non-invasive vascular lab studies.

## Training and Certification in Vascular Surgery

Because of the field's increasing complexity, having vascular surgery exposure during other residencies, such as general and cardiothoracic surgery, is no longer sufficient to acquire the appropriate judgment and skills necessary to practice vascular surgery. Completion of an ACGME-accredited vascular training program is necessary to achieve board certification in vascular surgery. Multiple training pathways have come about in an attempt to adapt to the various pressures facing vascular surgery training, including trainee's desire for shortened pathways, and vascular surgery's evolution as a distinct specialty. There are currently four ACGME-approved training pathways in vascular surgery [1]:

1. Traditional. This is the oldest but remains the most common method for obtaining vascular training. The candidate enters a 2-year ACGME-approved vascular residency following successful completion of a 5-year ACGME-approved general surgery training program.
2. Early Specialization. In the Early Specialization Program (ESP), the trainee completes 4 years of general surgery training followed by 2 years of vascular fellowship at the same ACGME-accredited facility. The selected candidate must be identified early so their program can be adapted such that the fourth year of training will be as a chief resident in general surgery. At this time, both the general and vascular surgery training must take place at the same institution. ESP graduates are eligible for both general and vascular surgery board certification.

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S.T. Smith (✉)

Assistant Professor, Division of Vascular & Endovascular Surgery, Department of Surgery, University of Texas Southwestern Medical Center, Dallas, TX, USA

3. **Integrated.** This pathway directly accepts graduating students from a Medical Doctor (MD) or Doctor of Osteopathic Medicine (DO) program into a 5-year vascular surgery training program. During the first 4 years, the trainee is exposed to 2 years of core general surgery and 2 years of vascular surgery. The final fifth year is devoted entirely to vascular surgery. Graduates of the integrated program are only eligible for board certification in vascular surgery.
4. **Independent.** This 6-year pathway includes 3 years of core general surgery training plus 3 years of vascular surgery training. The final year of the program serves as the chief resident responsibility on the vascular surgery service. All 6 years must be completed at the same ACGME-approved institution. Graduates from this pathway are only eligible for board certification in vascular surgery.

## Specific Requirements for Vascular Surgery Residents

### *Vascular Surgery*

The vascular surgery trainee should get broad exposure to open vascular surgery and is expected to have performed at least the minimum number of operations in each required area. The Residency Review Committee for Surgery (RRC-S) carefully evaluates and sets these requirements. The established minimum criteria for major open vascular reconstructive procedures include 30 abdominal vascular operations, 25 cerebrovascular, 45 peripheral, and 10 complex. In addition, the RRC-S guidelines set a minimum experience of 250 major vascular reconstructive cases that include open and endovascular operations. These are the 2008 recommendations but are continually reviewed and are subject to change.

### *Endovascular Interventions*

All vascular surgery residents are expected to have sufficient experience to perform vascular catheter-based interventions. The RRC-S has recently updated

the minimum numbers for endovascular cases, which includes 80 endovascular therapeutic procedures, 100 endovascular diagnostic procedures, and 20 endovascular aortic aneurysm repairs (EVAR). The experience should be balanced between the arterial and venous systems, with at least half of the diagnostic and 75% of the therapeutic procedures being performed on the arterial system [1]. The rationale for this is that venous interventions for dialysis grafts, and fistulas, and venous catheter placements should not constitute the major endovascular experience. Table 3.1 includes these requirements as well as guidelines for thoracic endovascular aortic repair (TEVAR) and carotid angioplasty and stenting (CAS).

### *Non-invasive Vascular Laboratory*

Vascular surgery fellowship programs must include training in non-invasive vascular lab studies. This includes the traditional vascular lab, including arterial and venous ultrasound studies, and the ability to analyze and manipulate three-dimensional (3-D) computer tomography (CT) reconstructions. three-dimensional reconstructions have become integral to the planning and surveillance of endovascular interventions like EVAR, angioplasty, and stenting. Adequate training for vascular ultrasound must include basic ultrasound anatomy, physiology and physics, and clinical ultrasound application to the treatment of vascular disorders. A minimum number of supervised interpretations of vascular studies in key areas should be performed as recommended by the Inter-societal Commission for Accreditation of Vascular Laboratories (ICAVL) (Table 3.2).

## Hospital Credentialing

### *New Vascular Graduates*

Physicians applying for vascular surgery privileges should have completed an ACGME-accredited vascular fellowship. All current training paradigms discussed above provide 2 years of vascular and endovascular training in addition to a core general surgery

**Table 3.1** Society for vascular surgery credentialing guidelines for endovascular procedures

	Number of cases	Number as primary operator
Endovascular diagnostic	100 <sup>a</sup>	
Endovascular therapeutic	80 <sup>a</sup>	
Endovascular aortic aneurysm repair (EVAR)	20 <sup>a</sup>	
Thoracic endovascular aortic repair (TEVAR)	10 within 2 years or 25 EVARs plus full endovascular privileges <sup>b,c</sup>	12 EVARs as primary
Carotid stenting (CAS)	25, plus 30 diagnostic cervicocerebral angiograms <sup>d</sup>	Half as primary Half as primary

Adapted from Calligaro et al. [1], with permission.

<sup>a</sup> Residency review for surgery established minimums for training.

<sup>b</sup> Physicians performing TEVAR should be familiar with the perioperative management of aortic surgical patients and are expected to have experience in performing adjunctive procedures for TEVARs, including iliac conduits, femoral exposures and repairs, and carotid–subclavian bypasses.

<sup>c</sup> Pre-existing open thoracoabdominal privileges are not a requirement.

<sup>d</sup> Diagnostic and stenting procedures may both be counted if performed during the same procedure.

**Table 3.2** Inter-societal commission for accreditation of vascular laboratories minimum guidelines for interpretation of vascular non-invasive studies

Non-invasive study	Minimum interpretations <sup>a</sup>
Peripheral arterial physiologic test	100
Peripheral arterial duplex scanning	100
Peripheral venous duplex scanning	100
Carotid duplex scanning	100
Transcranial duplex/Doppler scanning	100
Visceral vascular duplex scanning	75

<sup>a</sup> Physicians may seek privileges only in those areas where they have sufficient qualifications and training.

experience. The importance and increasing use of catheter-based interventions has been recognized by the ACGME through the RRC-S, which has made training in endovascular techniques a required component of vascular surgery training programs [2]. The need to develop increased expertise with endovascular procedures has led to the requirement for a minimum of 2 years of vascular surgery training. The endovascular training can be concentrated in 1 year or distributed evenly during the vascular fellowship. The minimum requirements of the RRC-S include 100 endovascular diagnostic cases, 80 endovascular therapeutic cases, and 20 EVARs. These should be distributed among the various vascular anatomic areas to establish competency in the treatment of patients with the complete breadth of vascular disease.

While there are no specific criteria for many subtypes of endovascular procedures such as subclavian

stenting, mesenteric angioplasty and stenting, thrombolysis, percutaneous mechanical thrombectomy, and embolizations, two specific procedures deserve mention. Specific guidelines have been published for credentialing in thoracic endovascular aortic repair (TEVAR) [3]. In addition to adequate training and exposure to thoracic aneurysm patients, anyone performing TEVAR should have knowledge of the perioperative management of thoracic aorta patients and have experience with adjunctive procedures often required with TEVAR. These include iliac conduits, femoral exposure, carotid subclavian bypass, and carotid–carotid bypass [1]. Requirements for TEVAR include basic endovascular privileges with an experience of 25 EVAR, 12 of which should be as the primary operator. Credentials for open thoracic surgery are not a requirement for TEVAR privileges.

A multi-disciplinary statement on training and credentialing for carotid stenting was published in 2005 [4]. Carotid stenting with embolic protection (CAS) is a relatively new procedure with the largest randomized controlled trial comparing CAS to carotid endarterectomy (CREST trial) ongoing [5]. The minimum numbers of procedures to achieve competence are 30 diagnostic carotid arteriograms and 25 carotid stent procedures, both with at least half as the primary operator (Table 3.1). These multi-specialty guidelines also state that the diagnostic and stenting portions may both be counted if performed during the same procedure. In addition to the procedural skills, the trainee must gain competency in the cognitive and clinical skills as well as judgment regarding care of the patient with carotid bifurcation disease.

## Credentialed Surgeons

Guidelines for vascular surgeons in practice are no different from those of vascular surgery residents entering practice. With rapidly advancing technology and new procedures, vascular surgeons should continue learning new procedures as the field evolves. Surgeons are expected to acquire proficiency in new procedures. For physicians trained in endovascular interventions, special training and certification may not be necessary. Credentialing for these new procedures and the training necessary will depend on the procedure's complexity and needs to be determined on a case-by-case basis.

## Maintenance of Certification

The ABS has instituted a Maintenance of Certification (MOC) program that goes beyond the traditional recertification process [6]. It is designed to give diplomates a greater opportunity to assess their practice and demonstrate their commitment to lifelong learning and practice improvement. ABS diplomates are automatically enrolled in MOC upon certification or recertification in any specialty after July 1, 2005. The MOC program consists of four parts:

- Part 1—*Professional standing* through maintenance of an unrestricted medical license, hospital privileges, and satisfactory references;
- Part 2—*Lifelong learning* through continuing education and periodic self-assessment;
- Part 3—*Cognitive expertise* based on performance on a secure examination;
- Part 4—*Evaluation of performance* in practice through tools such as outcome measures and quality improvement programs and the evaluation of behaviors such as communication and professionalism.

For vascular surgeons maintaining their specialty certification, the ABS will allow evidence of professional standing, lifelong learning/self-assessment, and evaluation of performance in practice (Parts 1, 2, and 4) that are performed in compliance with one certificate to be credited toward any other certificates the diplomate may hold. Maintenance of certification in general surgery is not mandatory for the maintenance

of vascular certification. The Society for Vascular Surgery has introduced the Vascular Education and Self-Assessment Program (VESAP) to meet MOC self-assessment requirements.

## Turf Battles

The area of peripheral endovascular interventions is an evolving one in which multiple specialties have expertise, including cardiology, interventional nephrology, interventional radiology, and vascular surgery. As there is no central credentialing process, each hospital must make credentialing decisions independently. In general, no specialty should hold territory over any specific anatomic area or specific procedure. Rather, if a physician can document proper training and show acceptable outcomes, the hospital should approve the credentials for that procedure. Each specialty has a different focus, and thus has some areas of expertise that are not shared. The best situation may be one where physicians from different specialties can work together and "cross-train." However, the political realities and competition between specialties often make this working relationship difficult to achieve.

## Summary

This is an exciting time in vascular surgery with the evolution of peripheral endovascular interventions. With expertise in both open surgery and endovascular techniques, the vascular surgeon has multiple tools to attack almost any vascular problem with which a patient may present. With each new technological advance, new vascular beds are amenable to minimally invasive treatment. Physicians must maintain proper training and ongoing experience to keep abreast of the latest advances.

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