

Endovascular interventions training and credentialing for vascular surgeons

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This article reviews issues concerning the training and credentialing of vascular surgeons in the use of endovascular techniques in the peripheral vascular system. These guidelines update a prior document that was published in 1993. They have been rewritten to accommodate the rapid evolution that has occurred in the field and to provide the appropriate requirements that a vascular surgeon should fulfill to be competent in the basic skills needed to safely and effectively perform all presently accepted diagnostic and therapeutic endovascular procedures. (J Vasc Surg 1999;29:177-86.)

This article reviews issues concerning the training and credentialing of vascular surgeons in the use of endovascular techniques in the peripheral vascular system (all arteries, veins, and lymphatic vessels, exclusive of the heart, ascending thoracic aorta, and intracranial vessels). These guidelines update a prior document that was published in 1993.¹ They have been rewritten to accommodate the rapid evolution that has occurred in the field and to provide the appropriate requirements that a vascular surgeon should fulfill to be competent in the basic skills needed to safely and effectively perform all presently accepted diagnostic and therapeutic endovascular procedures. The guidelines are on the basis of current methods by which vascular surgeons have acquired competence to perform endovascular interventions and may not be applicable to other inter-

ventional specialists. It is recognized that additional specific training may be needed before a given vascular surgeon can perform a specific endovascular manipulation or device placement as the field continues to develop.

SURGICAL PERSPECTIVE OF ENDOVASCULAR INTERVENTIONS

Endovascular interventions achieve a therapeutic result with instruments that are introduced into and through the lumen of a vessel. The balloon-catheter embolectomy and thrombectomy reported by Fogarty et al² in 1963 initiated the evolution of endovascular technology and was the first therapeutic use of a vascular catheter. In 1964, Dotter and Judkins³ introduced the concept of transluminal dilation with coaxial dilating catheters. The subsequent evolution of balloon angioplasty has been dramatic, with serial improvements in techniques and devices.⁴ Today, the use and application to various lesions still is being defined as *balloon technology*, and indications and limitations continue to evolve.

This developmental history has important implications for the training and credentialing guidelines for vascular surgeons who have a tradition of evaluating, treating, and following most patients with noncardiac vascular disease. Their skills have been developed through years of experience in treating patients with severe vascular disease and in performing complicated vascular reconstructions. Surgeons are experienced with the anatomy, pathology, and natural history of atherosclerosis and with the patient's response to a variety of treatment methods. For these reasons, surgeons have a valid perspective on the role of current

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endovascular methods. They also have experience with the corrections of many of the complications encountered during endovascular procedures.

Throughout the evolution of vascular surgery as a separate specialty (currently recognized by the American Board of Surgery with certificates of special or added qualifications), several key components related to the diagnosis and treatment of vascular disease have been emphasized. These components include the knowledge of the physiology, anatomy, and pathology of vascular disease and the development of multimodal diagnostic skills. Vascular surgeons pioneered and are well-versed in the performance and interpretation of noninvasive vascular diagnostic procedures. With particular reference to endovascular techniques, vascular surgeons routinely interpret and perform contrast arteriography, particularly in the operating room, and they perform a number of intravascular treatments. They also have pioneered the use of transluminally placed endovascular grafts for the treatment of aneurysms and for traumatic and occlusive arterial lesions.⁵⁻¹¹

NATIONAL GUIDELINES FOR PHYSICIAN CREDENTIALING

The Joint Commission for Accreditation for Health Care Organizations requires that specific privileges be delineated for each hospital staff member. Each hospital is required to monitor the appropriateness of the care provided by physicians and to provide the mechanisms to assess the new technologies before they can be used clinically. These directives have been accommodated in most instances by establishing departmental guidelines for new physicians or for physicians using techniques or methods that they have not previously used. For surgical procedures, this usually entails the observation of a specified number of procedures by a proctor and the option for the reporting of procedural outcomes both initially and after a long-term follow-up, if this is considered appropriate by the hospital credentialing body.

The qualifications required for a physician to perform a procedure are on the basis of skills acquired during residency or fellowship training, a supervised preceptorship, or approved courses when appropriate. Frequently, expertise in new technologies is developed during initial experimental trials of devices by physicians performing the studies under the auspices of institutional review boards and the Food and Drug Administration investigational programs. Thus, the means by which physicians obtain appropriate training to use new techniques can fol-

low a number of avenues, from formal training to the acquisition of skills during initial animal evaluations and clinical trials.

SPECIALTY GUIDELINES FOR PHYSICIAN CREDENTIALING

Endovascular device development and application has been influenced by various specialists—primarily surgeons, radiologists, and cardiologists—in the context of how the methods affect each group's primary patient population. Each specialty independently has arrived at training, credentialing, quality assurance, and educational guidelines for applications solely within its discipline (ie, coronary catheterization, cerebral angiography). Controversy and uncertainty have arisen when the guidelines are developed for areas of mutual interest (ie, noncoronary angioplasty, stent placement, and endovascular grafting procedures).

This controversy is complicated further because different patient groups may be treated, different criteria of success may be used, and each specialty emphasizes credentialing criteria on the basis of its tradition and the evolution of the endovascular techniques within its domain. Patients who are asymptomatic (minimal disease) or those with intermittent claudication (moderate disease) or limb-threatening ischemia (severe disease) can all be treated with identical techniques. The short-term and long-term success in each of these groups is expected to be different. Furthermore, whereas immediate hemodynamic or angiographic success is measured by some specialists, a long-term clinical evaluation, patency duration by duplex scanning, or hemodynamic success as measured in a noninvasive vascular laboratory are emphasized by others.

Each specialty has established preliminary criteria for the application of these endovascular methods on the basis of its interest and ability to treat a particular segment of the patient population and its tradition of equating expertise with numbers of procedures.^{1,12-16} The emphasis in several of these documents is on the credentials for percutaneous transluminal angioplasty, but the vascular surgery perspective is to address more broadly a large number of methods and techniques being developed. The guidelines for procedures in addition to percutaneous angioplasty will obviously evolve as technology advances and as safety and effectiveness are proven. Table I summarizes the number of recommended interventions for credentialing by the various groups, including those recommended in our 1993 Society for Vascular Surgery/International Society for Cardiovascular Surgery document and our

Table I. Number of catheterizations and interventions

	SCVIR	SCAI	ACC*	AHA*	SVS/ISCVS* (1993)	SVS/ISCVS* (1998)
Catheterizations/angiograms	200	100/50†	100	100	50†	100/50†
Interventions	25	50/25†	50/25†	50/25†	10 to 15†	50/25†
Live demonstration	yes	yes	yes	yes	yes	yes

SCVIR, Society of Cardiovascular and Interventional Radiology; SCAI, Society for Cardiac Angiography and Interventions; ACC, American College of Cardiology; AHA, American Heart Association; SVS/ISCVS, Society for Vascular Surgery/International Society for Cardiovascular Surgery.

*Includes knowledge of thrombolysis or thrombolytic therapy.

†As primary interventionist.

new Society for Vascular Surgery/International Society for Cardiovascular Surgery recommendations in this paper. The previous guidelines for vascular surgeons were criticized for requiring too few diagnostic and therapeutic angiograms and angioplasty procedures. The recommended guidelines that follow increase the number of qualifying interventions and establish parity with other guidelines. Our current guidelines promote the safe and efficacious performance of new and evolving endovascular techniques by vascular surgeons in a modern interventional environment.

The particular guidelines for each specialty should be benchmarks for physicians and hospitals in determining the appropriateness of individuals in each specialty to safely and effectively perform endovascular procedures. This is particularly important because each specialty's guidelines have been established and will evolve to accommodate new technologies predicated on the background, training, skills, and techniques used by physicians in each specialty. Thus, a particular specialty's guidelines should not be used to determine the appropriateness of application or credentialing for another specialty that has an entirely different perspective regarding the training and the methods of application. Controversial differences regarding indications and efficacy are issues that should be addressed separately from the credentialing criteria and differences that should be resolved by comparative or randomized clinical trials with recommended reporting standards.¹⁷⁻¹⁹ However, parity in the total number of procedures required for the credentialing of different specialties in endovascular techniques seems reasonable and appropriate.

VASCULAR SURGERY CREDENTIALING GUIDELINES

The credentialing for vascular surgeons who use endovascular techniques should be by 1 of 2 established methods. Privileges should be granted or

renewed either by the chief of the surgical services or by a hospital credentialing committee (whichever mechanism is operative in a particular institution). Privileges may be granted on the basis of verified training acquired during a vascular fellowship, by past practice experience, or through preceptorships or postresidency courses and practical training. In some cases, the training can be carried out in a surgeon's primary institution. In other situations, it may be obtained in another institution or with help from specialists from another institution. In any situation, postresidency training and experience must be obtained under the supervision of well-trained, experienced, and credentialed endovascular specialists.

The renewal of privileges is a less complicated consideration. Credentialing committees rely on many factors in their deliberations, including quality assurance and morbidity and mortality data. The assessment of the use of particular procedures and recommendations for quality review is not a focus for the current discussion and is addressed in other documents.¹⁸⁻²⁰

Additional factors, such as course or symposium attendance and didactic and hands-on in vitro or in vivo animal model or patient experience, are most appropriately considered. One-day or 2-day training in the use of a new device may be appropriate for experienced vascular surgeons familiar with all aspects of endovascular device use, but this limited exposure may be inadequate under most circumstances for surgeons with no such experience.

Vascular surgery training encompasses a complete spectrum of skills and cognitive components. Vascular surgeons not only have special expertise in correlating operative anatomy with preoperative diagnostic information but also have experience with long-term follow-up and pathologic correlation in failed and successful procedures. Vascular surgeons are uniquely qualified to evaluate and treat limb-threatening and

Table II. Antegrade common femoral puncture selective vessel ordering

<i>First order family</i>	<i>Second order family</i>	<i>Third order family or beyond</i>
Superficial femoral artery		Anterior tibial artery Posterior tibial artery Peroneal artery Tibioperoneal trunk artery
Deep femoral artery	Lateral circumflex artery Medial circumflex artery	

life-threatening complications of endovascular procedures. The experience that is acquired regarding use, indications, and appropriate anticipation of possible complications makes vascular surgical consultation an important component of certain types of endovascular therapy. In many respects, the vascular surgical position on credentialing requirements for training is influenced by these factors and must consider the role of experience acquired during training on recommendations for certifying additional skills required for endovascular methods.

Concepts related to credentialing in endovascular surgery

Credentialing in endovascular therapy is on the basis of the performance of a minimum number of a variety of procedures that show a sufficient exposure to the fundamental endovascular techniques to expect that the competence to perform all presently approved endovascular diagnostic and therapeutic procedures has been attained. It is readily acknowledged that new procedures will be developed over time and that many of these developments will ultimately be incorporated into the endovascular armamentarium. The foundation of endovascular skills encompassed by this minimum credentialing experience should allow for the assimilation of these new techniques with only a modest supplemental training that is specific to the new device or procedure involved. Thus, as in other fields of medical practice, it is anticipated that there will be an evolution of procedures within each physician's practice and that this process will begin with the attainment of the credentials to perform the presently accepted diagnostic and therapeutic endovascular procedures.

The fundamental skills necessary to perform all endovascular procedures can be categorized in the following manner: gaining access to the vascular system; positioning catheters in various locations; treating conditions by endoluminal dilatation or device deployment; and assessing the situation before, during, and after treatment. Vascular surgeons are proficient in the

assessment of the vascular system and in obtaining operative vascular access but may have limited experience in catheter/guidewire skills. Accordingly, the credentialing requirements for vascular surgeons reflect the need to show expertise with those components of endovascular care that are typically not included in vascular surgical training. With this in mind, the training and credentialing requirements and definitions that will follow emphasize specific skills, such as catheterizations, rather than procedures that are less demanding in terms of manipulative skills, such as angiograms. Furthermore, they recognize the diversity of vascular practice by allowing a variety of endoluminal procedures to be counted toward the various requirements although setting limits on the contribution of some procedures to the total requirements to preserve balance and ensure a broad-based training experience. Lastly, in a fashion analogous to the way endovascular procedures are current procedural terminology coded for billing purposes, it is possible to obtain credentialing credit for more than 1 endovascular skill or procedure that is performed on a single patient during the same session.

Fundamental to understanding the credentialing guidelines is an understanding of the applicable definitions that are listed below:

Catheterization is the general term used to denote the positioning of a catheter in a specific location of the vascular system, often, but not always, with the assistance of a guidewire.

Direct catheterization is used to describe the simple placement of a catheter directly into a vessel without the use of guidewire advancement of the catheter any further into the vascular system involved. For example, this refers to the placement of an intraluminal catheter into the femoral or brachial arteries for angiographic evaluation of the leg or arm or to direct needle puncture of a bypass graft to perform completion angiography. Although sometimes used for diagnostic purposes, such procedures are not generally counted as "catheterizations".

Selective catheterization refers to the placement of

Table III. Retrograde common femoral puncture selective vessel ordering

<i>First order family</i>	<i>Second order family</i>	<i>Third order family or beyond</i>
Innominate artery	Right common carotid artery Right subclavian/axillary artery	Right internal carotid artery Right external carotid artery Right vertebral artery Right internal mammary artery
Left common carotid artery	Left internal carotid artery Left external carotid artery	
Left subclavian/axillary artery	Left vertebral artery Left brachial artery, proximal to profunda Left internal mammary artery	Left brachial artery, distal to profunda
Celiac axis artery		
Superior mesenteric artery Either renal artery Ipsilateral hypogastric artery Contralateral common iliac artery	Contralateral external iliac artery Contralateral internal iliac artery	Contralateral common femoral artery Contralateral superficial femoral artery Contralateral profunda artery Distal branches of above Contralateral superior gluteal artery Contralateral ileolumbar artery

Note: branches beyond third order classification are not further subdivided and are collectively referred to as “third order or beyond” branches

a catheter in a branch vessel of the aorta, vena cava, or of the vascular tree beyond the point of introduction of the catheter into the vascular system. Whenever the catheter is first advanced into the aorta or vena cava on its way to its final destination, the aorta or vena cava is considered a nonselective catheterization and is the starting point for subsequent selective catheterizations. Depending on how distal into the vascular tree the catheter is positioned beyond this starting point, selective catheterizations may be termed a “first,” a “second,” or a “third” order catheterization. For example, either of the renal arteries, the left common carotid or subclavian arteries, and the common iliac artery contralateral to the side of femoral artery puncture are all first order catheterizations, and the right common carotid and subclavian arteries are second order catheterizations. Although the left vertebral artery is a second order catheterization, the right vertebral artery is a third order catheterization because the catheter must be advanced through the innominate artery (first order vessel) and the right subclavian artery (second order vessel) on its way to the right vertebral artery. When an antegrade femoral artery puncture is used to evaluate a lower extremity, the common femoral artery is the starting point for subsequent catheterizations, such as placement of a catheter in the superficial femoral artery would be a first order catheterization but the anterior tibial artery would be considered a third order vessel. With regard to tallying the procedures performed, however, only the highest order

catheterization of a specific vascular branch is counted, not all of the more proximal vessels traversed on the way there. For example, bilateral selective common carotid artery catheterizations would be counted as 1 first order (left carotid) and 1 second order (right carotid) catheterization. No credit would be given for passing through the innominate artery on the way to the right common carotid artery. Tables II and III diagram these relationships more fully.

An *intervention* is a therapeutic procedure on a vessel, such as a balloon dilatation, atherectomy, stent placement, caval filter placement, or endoluminal graft implantation. Multiple interventions performed at the same sitting can all be counted toward the credentialing requirements, as can associated diagnostic catheterizations. For example, when a balloon dilatation proves to be an insufficient treatment and requires the placement of a stent to achieve a successful result, both procedures are counted as interventions. However, if the stent placement is the initial procedure performed (termed *primary stenting*), the balloon dilatation that is used to deploy or fully expand the stent is not counted as a separate procedure. Similarly, unsuccessful atherectomy that requires subsequent balloon dilatation would count as 2 interventions. Interventions on 2 different arterial segments, such as distinctly separated lesions of the common and external iliac arteries, are counted as 2 interventions, as is a “kissing” balloon dilatation of the common iliac artery origins.

Requirements for credentialing in endovascular procedures

Board eligibility for, or current certification of, special or added qualifications in peripheral vascular surgery is recommended but not required for new applicants for credentials in endovascular surgery. The absence of this should not be a cause to rescind previously granted endovascular credentials. To be considered sufficiently experienced in the fundamental endovascular skills needed to undertake the full spectrum of accepted endovascular diagnostic and therapeutic procedures, a vascular surgeon should be able to document senior-level participation in at least 100 catheterizations and 50 therapeutic interventions. The surgeon must have acted as the primary interventionist (ie, performed the critical components) on at least half of these procedures and been no less involved than a first assistant on the remainder. In addition, the vascular surgeon must document the performance of at least 25 percutaneous arterial cannulations, all as the primary surgeon, with the Seldinger technique. When this experience is attained during a period of formalized training, such as a vascular fellowship, each physician who serves as a mentor must have the endovascular experience sufficient to meet these requirements. Similarly, when the endovascular training occurs through a preceptorial arrangement after the completion of formal postgraduate training, each preceptor for the vascular surgical trainees must be able to qualify for endovascular privileges under these requirements. The vascular surgeons who have learned endovascular techniques on their own and who have sufficient experience to meet these case requirements may have to document their safety and efficacy to be granted endovascular privileges. In both the preceptorial and the self-taught situations, the requisite case volume should have been attained within a period of time that is no longer than 3 years to ensure that an adequately concentrated training experience occurred and that the surgeon has a sufficiently active vascular practice to anticipate maintained endovascular expertise.

Of the 100 required catheterizations, at least half should be selective catheterizations to ensure mastery of the catheter/guidewire skills that are necessary to position catheters in these more specific locations. Furthermore, 75% or more of the 100 required catheterizations should be arterial, and up to 25% can be venous. Similarly, at least 75% of the 50 requisite therapeutic interventions must be performed on arterial lesions, and the remainder can be venous or dialysis graft procedures. These stipulations recognize the variety of vessels that are treated by endovas-

cular means and the diversity of approaches that are used, and they maintain a broad-based and balanced endovascular training experience. Lastly, there is no specific requirement for thrombolysis case experience because the principal technical skills involved in these procedures relate to the ability to gain access to the vascular system and to position catheters in selective locations, which are skills already encompassed by the catheterization requirements. However, it is expected that vascular surgeons who perform endovascular interventions will be knowledgeable about thrombolytic infusion catheters and wires and about the recommended infusion rates for the various thrombolytic drugs they may use.

Endovascular case scenarios

Example 1. Diagnostic angiography is undertaken to evaluate a patient with disabling left lower extremity claudication. Vascular access is obtained to the left common iliac artery via a percutaneous retrograde right common femoral artery puncture. A pigtail catheter is advanced over a guidewire into the perirenal aorta, and a subsequent power injection of contrast shows a significant stenosis of the left external iliac artery. Balloon dilatation of this lesion is performed via the femoral artery access site. After the dilation, there is still a significant residual stenosis, so a stent is placed across the lesion, which eliminates the stenosis and concludes the procedure.

This case would fulfill the following requirements:

One percutaneous access (the retrograde right femoral puncture).

One selective arterial catheterization (the balloon catheter in the contralateral external iliac artery; second order catheterization). The nonselective catheter in the aorta is not counted because it was simply the starting point for the higher order selective catheterization of the left external iliac artery.

Two arterial interventions (the balloon dilatation and the subsequent stent).

If, in this procedure, the therapeutic approach to the left external iliac artery was via a percutaneous retrograde left femoral artery puncture, the total catheterizations and procedures would become:

Two percutaneous arterial accesses (the diagnostic right and the therapeutic left retrograde femoral artery punctures).

Two nonselective arterial catheterizations (the diagnostic catheter in the aorta and the therapeutic catheter in the external iliac artery).

Two interventions (the balloon dilatation and the subsequent stent).

Example 2. A patient undergoes diagnostic

cerebrovascular angiography via a percutaneous retrograde right femoral artery puncture. Flush arch aortography is performed through a pigtail catheter positioned in the ascending aorta to evaluate the aortic arch and the origins of the great vessels. The pigtail catheter then is exchanged for a selective catheter that is sequentially positioned in both the right and left common carotid arteries so that angiography of these vessels can be performed, after which the procedure is concluded.

This case would fulfill the following requirements:

One percutaneous access (the retrograde right femoral puncture).

Two selective arterial catheterizations (the first order left common carotid and the second order right common carotid).

Example 3. A patient who needs a vena cava filter is brought to the angiography suite or to an operating room equipped with digital fluoroscopy and undergoes inferior vena cavography via a percutaneous internal jugular vein puncture. A pigtail catheter is placed in the inferior vena cava and power injection venography is performed. The location of the renal veins is not readily apparent, so the pigtail catheter is exchanged for a selective catheter that is used to catheterize both the right and the left renal veins, after which the caval filter is successfully placed.

This case would fulfill the following requirements:

Two selective venous catheterizations (the 2 renal veins; both first order).

One venous intervention (the caval filter placement).

Note that the percutaneous venous puncture is not counted as a requirement because only arterial punctures are counted. The nonselective vena caval catheterization is not counted because higher level venous catheterizations are counted.

Example 4. Previous diagnostic angiography has shown high-grade stenoses in both the left mid superficial femoral artery and the left popliteal artery at the level of the knee. Balloon dilatation of these lesions is performed with access accomplished via a percutaneous antegrade left femoral artery puncture.

Both of these procedures are successful, and the case is terminated.

This case would fulfill the following requirements:

One percutaneous access (the antegrade left common femoral puncture).

One selective catheterization (the catheter in the popliteal artery; second order catheterization).

Two arterial interventions (the balloon dilatation of the mid superficial femoral and the popliteal arteries).

Example 5. A patient with ischemic gangrene has an angiographically shown high-grade stenosis of his common iliac artery (at the site of a previous dilatation) and complete occlusion of his superficial femoral artery with reconstitution of his posterior tibial artery. He is brought to the operating room for femoral-tibial bypass grafting and undergoes intraoperative balloon-deployed primary stenting of his common iliac artery to provide adequate inflow, after which his bypass grafting is performed. A completion arteriogram of the bypass graft then is performed by the direct puncture of the graft, which concludes the procedure.

This case would fulfill the following requirements:

One nonselective arterial catheterization (the balloon catheter in the common iliac artery).

One arterial intervention (the primary stenting of the common iliac stenosis that is counted as only 1 procedure because balloon dilatation alone was not attempted).

The direct graft puncture catheterization is not counted toward the catheterization requirement.

Note that because this is a surgically exposed femoral artery, no percutaneous access credit is given.

Example 6. A patient with a presumed popliteal embolus is brought to the operating room and undergoes a balloon-catheter embolectomy. Operative angiography that is performed through the femoral arteriotomy reveals thrombus in all of the trifurcation vessels. With fluoroscopic guidance, the balloon catheter is manipulated into the peroneal, anterior, and posterior tibial arteries to successfully extract the thrombotic material. Angiographic re-evaluation confirms a complete clot extraction, but a high-grade popliteal artery stenosis is shown and is successfully balloon dilated, after which the procedure is concluded.

This case would fulfill the following requirements:

Three selective arterial catheterizations (the balloon catheter passages into the peroneal, anterior tibial, and posterior tibial arteries).

One intervention (the balloon dilatation of the popliteal artery); note that the balloon catheter placement into the popliteal artery to perform the dilatation is not counted because higher order branches of the same vascular family were already credited.

The open arteriotomy angiogram would not be counted toward the catheterization requirement, nor would credit be given for vascular access because this was performed via a surgically exposed vessel.

INTERVENTIONAL IMAGING METHODS

The performance of endovascular procedures relies heavily on obtaining high-quality fluoroscopic,

angioscopic, or intraluminal ultrasound scan images of the vascular segments being treated before, during, and after the interventions. The performance, interpretation, and determination of the use of a particular imaging method are essential prerequisites for credentialing approval. Vascular surgeons are expert at the use of radiologic imaging for assessing vascular anatomy before, during, and after interventions. Many vascular surgeons are skilled at passing intraluminal imaging devices, such as angioscopes and intraluminal ultrasound scan catheters, and at using digital fluoroscopy. These skills may be acquired during fellowship training, through specialized training courses, or by preceptorship with an experienced interventionist (surgeon, radiologist, or cardiologist). If necessary, additional training in the use of imaging devices can be obtained through didactic and hands-on instruction, which includes the performance of the procedure and an interpretation of acquired data.

The performance of radiographic studies involves complex issues that are related to radiation safety and special training required for the operation of fluoroscopic and radiographic imaging systems. Vascular surgeons are highly qualified in the interpretation of vascular contrast studies, although there is variability in the experience of performing percutaneous angiography. Many senior surgeons were trained in angiography and have performed their own procedures for many years, and a limited number of vascular surgeons still routinely perform arteriographic studies. In general, vascular surgeons independently interpret angiographic studies performed outside of the operating room, and they also perform and interpret arteriography in the operating room in addition to evaluations before and after reconstructive procedures. Surgeons should have performed at least 100 catheterizations and arteriographic procedures to obtain generalized credentialing in endovascular procedures. The site at which these procedures are performed is not of critical importance.

One of the widely used credentialing documents recommends that formal angiographic training include the assessment of arteries from the aorta through the vessels in both lower extremities with images captured on fixed film.¹⁶ Because this requirement frequently mandates a more extensive procedure than needed, this requirement should be reassessed and is not a part of the present document. Furthermore, cinevideofluoroscopy and digital data storage have replaced the film recordings of proce-

dures in many modern endovascular suites. The recommendations in the current document allow vascular surgeons to comply in a way that is consistent with the needs of contemporary practice and avoids recommendations, which involve a requirement for fixed film angiographic techniques.

Differences exist in the quality of the images obtained with older portable C-arm fluoroscopic units available in most operating rooms when compared with the images acquired from high-resolution systems that are present in many interventional radiology and cardiology suites. However, new C-arm units have overcome most previous limitations and are becoming readily available. Although it is paramount that good imaging methods be available (in particular freeze-frame subtraction and roadmapping techniques) to obtain reproducible, high-quality results with endovascular devices, it is becoming increasingly apparent that angiography alone is limited in the degree of precision that it provides for guidance during the insertion of devices and in the determination of the amount of a lesion to be removed. Intravascular ultrasound scan can overcome many of these limitations and may become a more important imaging method in the future. This discrepancy has been documented by many studies and is exemplified by the finding that arteriography significantly overestimates the amount of lesion removed and the residual lumen size after angioplasty or atherectomy as compared with that obtained with intravascular ultrasound scan, which more accurately assesses plaque and lumen area.

SPECIFIC DEVICE TRAINING

As each new method emerges, the question arises: what constitutes adequate training for surgeons planning to use the device clinically? In most instances, a surgeon who is trained in endovascular techniques can quickly adapt to new devices and must only be trained in specific safety issues, limitations, and indications. This training usually can be accomplished with a didactic lecture session and *in vitro* or *in vivo* animal laboratory training.

The use of particular devices is predicated on the surgeon's ability to perform the basic endovascular maneuvers (lesion access, imaging, and guidewire passage), a demonstration of knowledge of the function of and the indications for the device, and a familiarity with the safety considerations pertinent to a particular instrument. In this regard, most devices can be used without special certification after the acquisition of the fundamental knowledge regarding

the device. Specifically, a trained vascular surgeon should be able to safely use angioscopes and intravascular ultrasound scan catheters without specific supplemental credentialing. Likewise, a new form of atherectomy catheter can be used safely if the surgeon has basic core endovascular skills and becomes familiar with the new device.

Intravascular stents are being investigated widely for the treatment of lesions in the aorta, the iliac and renal arteries, and other arteries. The preliminary results of studies with these devices in larger diameter (>7 mm) arteries are favorable, and the use of stents in smaller arteries, aside from coronary and renal applications, has been limited by poor preliminary results and will require significant additional development and investigation. Stents are being used by radiologists, cardiologists, and vascular surgeons. In addition, surgical interest in stents is increasing because they are used as the fixation mechanism for intraluminal aortic grafts. Many prototype systems for intraluminal graft deployment are being developed, with surgeons leading this effort. This technique may be the first endovascular method that stimulates widespread surgical involvement, particularly because it encompasses the treatment of aortic and large vessel aneurysms, which is currently considered primarily within the domain of vascular surgeons.

The developments in endovascular technologies not only involve devices but also pharmacologic agents, such as thrombolytic agents. Drug therapy has not been addressed in most credentialing documents, but it does constitute an important therapeutic method that deserves ongoing evaluation. From a surgical perspective, knowledge of drug therapy is routinely incorporated in all vascular surgical training programs and is continually updated as advances occur.

CONCLUSION

Many endovascular interventions and devices have had their initial development and clinical assessments completed and are being used by radiologists, cardiologists, and surgeons to treat vascular disease. Conventional vascular surgical training includes an evaluation of the role and application of surgical and nonsurgical measures and endoluminal techniques. As the endovascular technologies have improved, however, vascular fellowship training programs have incorporated them into the programs. Vascular surgeons who have completed their training and who desire to include these techniques in their surgical practice should meet the outlined minimal creden-

tialing criteria. An additional important factor in determining the appropriate use of endovascular techniques is physician judgment and patient selection, which do not necessarily equate to the number of procedures performed.

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APPENDIX. COMMITTEE ON ENDOVASCULAR ISSUES.

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