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Endovascular Training of Vascular Surgeons: Have We Made Progress?

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The rapid evolution of catheter-based technologies during the last 5 years has created a critical need for development of effective resident level and postgraduate education programs in both open and endovascular techniques and associated cognitive and clinical skills. Currently, significant variability exists in endovascular training formats and in the number of endovascular procedures performed during the course of a graduate or postgraduate program. Little information on the quality of these programs exists and in the subsequent practice patterns of the trainees. This report reviews recommended credentialing requirements, training paradigms, and the growing experience of vascular surgical trainees since 2000.
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SINCE SELDINGER'S FIRST description of utilizing a catheter to replace the needle for diagnostic arteriography in 1953, the field of minimal invasive endovascular intervention has evolved significantly.[1] Dotter and Judkin revolutionized the treatment of arterial disease by introducing arterial dilation with a rigid Teflon catheter,[2] while Gruentzig, in 1974, introduced balloon angioplasty, which, to date, remains the most commonly performed endovascular procedure.[3] Over the last two decades, management of vascular disease has taken a quantum leap forward with a greater emphasis on catheter-based intervention, as Julio Palmaz pioneered the intravascular balloon expandable stent in 1985[4] and Juan Parodi developed the first aortic stent graft in 1991.[5]

The continual evolution of catheter-based technologies has created a need for updating and educating physicians on new treatment paradigms. These new challenges facing the vascular surgeon have been recognized as the contemporary philosophy in vascular training programs emphasizing the proficiency in both open and endovascular techniques. However, the amount of training in endovascular techniques and the number of endovascular procedures performed vary dramatically among vascular surgeons. Although there are many training programs available, we have little information on the quality of the programs and the practice of the trainees following the programs. Thus, the important question remains, have we made any progress over the last decade?

Endovascular Progress on Vascular Diseases

Vascular surgeons and patients have enthusiastically embraced the minimally invasive endovascular therapy because of the reduced procedural-related discomfort, faster recovery, and decreased hospital stay. Additionally, endovascular interventions decrease operative time and blood loss with potential improved overall morbidities and mortality compared with its open surgical counterpart, particularly for patients with significant medical comorbidities. Over the last two decades, endovascular technologies and devices have undergone rapid innovation, evolution, and refinement. By itself or combined with an open technique, percutaneous interventions have become an integral part of therapeutic regimens, particularly in the fields of aneurysm repair, as well as carotid and peripheral arterial disease.

The role of endovascular intervention has expanded considerably in the treatment of aortic aneurysms. Currently, there are four US Food and Drug Administration (FDA)-approved devices in the United States for elective repair of an infrarenal abdominal aortic aneurysm, including AneuRx (Medtronic, Santa Rosa, CA), Excluder (W.L. Gore, Flagstaff, AZ), Zenith (Cook Inc. Bloomington, IN), and Endologix Powerlink (Endologix, Irvine, CA). Endologix is a unibody device that is anchored at the aortic bifurcation and extends proximally, while the remaining three are all modular devices consisting of a main body and iliac limbs that insert into the

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main body to complete the repair. As for treating thoracic aortic aneurysms, TAG thoracic endoprosthesis (W.L. Gore) has been approved by the FDA; and several other devices are currently under intense investigation.

Carotid artery stenting, as an alternative to endarterectomy for carotid atherosclerotic disease, has gained increasing acceptance in the medical community. Several large multicentered clinical trials have proved the efficacy of carotid stenting.[6,7] A study reported by our group also demonstrated CAS with routine use of a cerebral protection device as a feasible alternative in high-risk patients with an overall success rate of 98% and combined perioperative stroke and death rate of 2.5%.[8] To date, Guidant (Santa Clara, CA) Carotid Stenting system using RX ACCULINK with an RX ACCUNET embolization protection device has been approved by the FDA. Several other devices are also currently under evaluation in clinical trials.

Percutaneous lower extremity intervention, one of the most diverse areas of the endovascular field, has experienced rapid growth over the last decade. The treatment spectrum ranges from transluminal and subintimal angioplasty, through atherectomy and brachytherapy, to endoluminal stent and stent-graft placement. Increased popularity of endovascular approaches for lower extremity diseases has prompted a new classification of lower extremity atherosclerotic lesions based on the anatomic and morphological characters. According to TransAtlantic Inter-Society Consensus, type A lesions are short and nonocclusive, which can be treated primarily with percutaneous techniques, while type D lesions are long segments of stenosis or occlusions that should be treated surgically. However, with further advancement in technology and the refinement of devices, more lesions will be amendable to endovascular interventions and better long-term outcomes will be achieved.

Is There a Crisis in the Current Training Paradigm?

The explosion of endovascular techniques, along with an influx of therapeutic options for cardiovascular diseases over the last two decades, have shaped the practices of multiple specialties, particularly interventional radiology, vascular surgery, and cardiothoracic surgery. This shift in practice patterns has affected the strength and the growth of the aforementioned specialties, which in turn has had an impact on their ability to recruit trainees. A healthy applicant pool often reflects the quality of the trainees and the ability of a specialty to attract competent individuals, which can be indicative of the future health of a specialty.

Cardiothoracic surgery, for example, has experienced a significant reduction in open surgery secondary to the rapid expansion of minimally invasive interventions and with steady improvement in device performance, such as that observed with drug-eluting coronary stents. Therefore, the demand for cardiothoracic surgeons has been reduced and job availability has become limited. These conditions have resulted in the phenomenon of fully trained cardiothoracic surgeons seeking additional trainings because they are unable to find a job or as a hedge against a difficult job market.[9] As a consequence, the applicant pool for cardiothoracic training programs has declined. Interventional radiology, on the other hand, has experienced poor recruitment with unfilled fellowship positions over the last few years despite an overall increase in the amount of percutaneous interventions. This reduction in applicant pool is largely associated with intensified competition from other specialties that has led to a decrease in diagnostic and interventional vascular procedures performed by the radiologist. Additionally, lifestyle issues, negative attitudes among fellow and staff interventionalists toward the field, and lack of good mentors are also discouraging factors.[10]

Vascular surgery is currently at a crossroad where the current and future practices are being intensely debated. The constantly evolving endovascular techniques and growing competition among different specialties create enormous opportunities, as well as considerable uncertainty. One of the rising concerns among the vascular community is the decrease in US applicants and unfilled vascular fellowship positions in the 2004 National Residency Matching Program. The Association of Program Director in Vascular Surgery investigated the characteristics and trends of the applicant pool and realized that while the overall number of vascular surgery applicants has remained relatively stable, the number of vascular fellowship positions has significantly increased and the number of US applicants has decreased, particularly fewer female applicants.[11] This decline in US vascular surgery applicants also reflects reduction in general surgery resident pool as decreasing number of medical students selecting surgery as a specialty, despite the introduction and reinforcement of the 80-hour work rule by the Resident Review Committee in 2003. The 80-hour rule is intended to improve the well-being and learning experience of surgical residents and ultimately to attract more qualified medical students. However, restricted working hours limit resident exposure to subspecialties and may potentially impede development of interest in vascular surgery and other subspecialties. A survey conducted by Association of Program Director in Vascular Surgery showed that technical aspects, the role of mentors, and complex decision-making involved in vascular surgery were the most important reasons trainees would choose vascular surgery as a specialty.[12] Endovascular capabilities of vascular surgeons have an increasingly positive role in career choice by general surgery chief residents and vascular fellows. However, the concern of potential loss of patients to other specialists was the major negative factor among vascular and general surgery residents, while lifestyle concerns and length of training were the most important reasons medical students did not choose vascular surgery as a career.

The widespread concern of current vascular training programs and the increased demands on the trainees to learn not only the fundamental knowledge of vascular diseases but also the modern therapeutic modalities have triggered interests in reevaluating the conventional surgical training programs. A new training paradigm focusing on all aspects of vascular diseases with shorter training time appears necessary to at-

tract the most talented and qualified trainees. The new vascular training paradigm will offer an opportunity for a disease-specific vascular specialist with patient-focused expertise in vascular surgery, endovascular therapy, and vascular medicine. Therefore, mentorship of vascular surgeons and competency in both endovascular and surgical skills among the vascular surgeons has become imperative for the health of future vascular specialty.

Is There a Need for Endovascular Training?

The evolution of endovascular therapy has transformed the treatment paradigm for vascular disease, a field largely shared by vascular surgeons, interventional radiologists, and cardiologists. Among them, the vascular surgeon has the unique advantage of providing all aspects of patient care, including preoperative evaluations and risk factor modifications, perioperative care, and postoperative patient follow-up. After all, vascular surgeons have the most in-depth understanding of the nature of vascular disease and can offer a broad range of therapeutic modalities. The addition of catheter-based skills to our armamentarium further allows us to provide optimal care for our patients and to compete with other interventional specialties.

To achieve endovascular competency, one needs to acquire sufficient experience to overcome the initial steep learning curve. Various endovascular training programs undoubtedly play an essential role in hastening the learning process as demonstrated by multiple studies. Lobato and colleagues[13] evaluated 277 consecutive patients who underwent endovascular repair of infrarenal aortic aneurysms and showed that not only was the number of procedures important to the outcome, but also the frequency with which they were performed. Based on their study, 55 cases appear to be the minimum volume and one case every 10 days the minimum frequency to obtain quality operative results with aortic endografting. Similarly, we recently analyzed our data on 200 consecutive patients who underwent carotid artery stenting procedures and demonstrated excellent outcomes of carotid artery stenting with neuroprotection.[8] More importantly, our experience confirmed a procedural-associated learning curve, as evidenced by reduced procedural-related complications, fluoroscopic time, and contrast volume occurring with an increase in physicians' experience. Additionally, the procedural success was also enhanced partly by the refinement of endovascular devices and improved anticoagulation regimens.

In response to the important learning curve of endovascular procedures, several specialties independently arrived at training, credentialing, quality assurance, and educational guidelines. Each specialty 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.[14] For example, the training standard and credentialing guideline for endovascular abdominal aortic aneurysm repairs vary greatly. The Society of Cardiovascular and Interventional Radiology recommended 200 diagnostic procedures and 25 interventional procedures, while the American College of Cardiology, American Heart Association, the Society for Cardiovascular Angiography and Interventions (SCAI), and the Society for Vascular Surgery/International Society for Cardiovascular Surgery (SVS/ISCVS) recommended 100 diagnostic procedures and 50 interventional procedures. Furthermore, SCAI and SVS/ISCVS also required at least half of the performed procedures as primary operator. Similarly, different guidelines have been introduced for endovascular carotid artery interventions. A more balanced statement was recently published jointly by several societies including SCAI, the Society for Vascular Medicine and Biology, and SVS.[15] In this document, it is recommended that a physician perform at least 30 cerebral angiograms and 25 carotid artery stents, with at least half as primary operator, in order to obtain the minimum clinical competency in carotid interventions. In addition to these recommended guidelines, this document emphasizes the various means for physicians to acquire the necessary skills and training in carotid artery stents, including industry-sponsored courses and carotid simulation training modules.

Current Endovascular Training Programs and Progress

Rapidly increasing interest in endovascular interventions among members of the medical community and patients who may benefit from these new technologies have prompted the development of various endovascular training programs with an emphasis on the acquisition of catheter-based skills among the vascular fellows trained over the last several decades.

Endovascular Progress in Vascular Fellowship Training

The increased demand for endovascular-competent surgeons has fundamentally changed the vascular surgery training program. We analyzed published statistical data from the Accreditation Council for Graduate Medical Education, which summarizes procedures performed by vascular surgery fellows over the last 4 years. The total therapeutic and diagnostic endovascular procedures performed by the vascular fellows has increased consistently from 2000 to 2004. As demonstrated by Fig 1, the average number of diagnostic procedures performed by the fellows increased from 22.2 to 86 procedures per fellow over 4 academic years. Similarly, the average number of therapeutic procedures has increased from 41.5 procedures per fellow in the 2000-2001 academic year to 101.7 procedures per fellow at 2003-2004 academic year. More importantly, over a 4-year period, the total number of diagnostic and therapeutic procedures conducted by vascular fellows in the United States increased from 10,094 to 31,606 and from 7,026 to 18,760, respectively (Fig 2). Furthermore, the amounts and types of major open surgical procedures performed by these fellows has not changed sig-

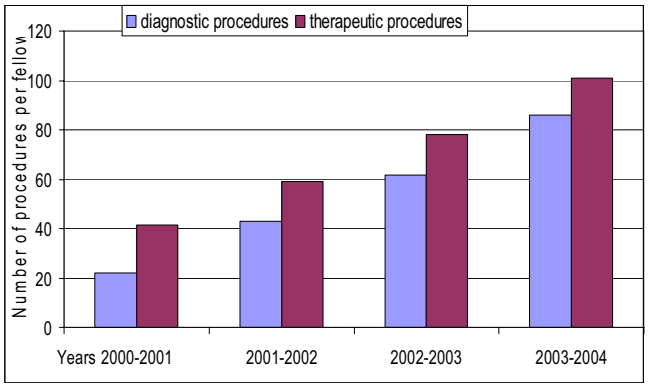

Figure 1 Average number of diagnostic and therapeutic procedures performed each year by vascular fellows during the period 2000-2004.

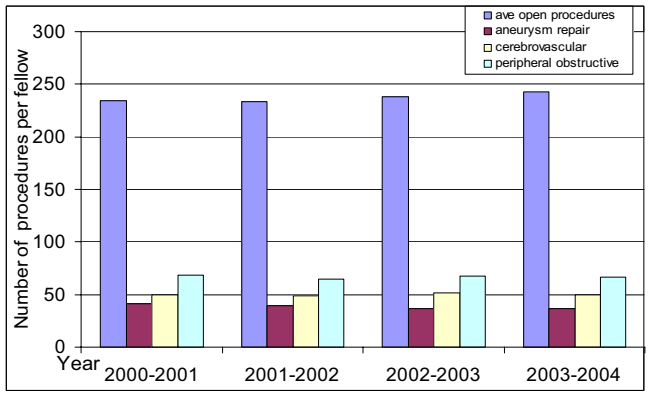

Figure 3 Average number of open surgical procedures performed each year by vascular fellows during the period 2000-2004.

nificantly from an average of 234.6 procedures per fellow in 2000-2001 academic year to 242.5 per fellow during 2003-2004 academic year (Fig 3). However, the number of procedures performed by any given fellow varies significantly, as evident by a standard deviation of 31 for diagnostic procedures and 34 for therapeutic procedures in the 2000-2001 academic year, with an increase in standard deviation to 53 during the 2003-2004 academic year for both diagnostic and therapeutic procedures.

Endovascular Training Programs for Practicing Surgeons

An increasing number of intense training courses, including "mini-fellowships," industry-sponsored training courses, and medical simulations, offer additional opportunities for practicing vascular surgeons who need to acquire catheter-based skills. Currently, there are 15 SVS Endovascular Program Evaluation and Endorsement Committee sponsored "mini-fellowships" available. These courses range from 1 to 3 months and are intended to equip vascular surgeons with the appropriate knowledge and skills to perform endovascular procedures effectively and independently. Additionally, multiple industry-sponsored endovascular workshops are readily available ranging from basic endovascular procedures, such as diagnostic angiography and iliac stenting, to highly specialized interventions, such as carotid artery stenting and thoracic endografting. These workshops vary from teaching conferences to hands-on practice and typically last 1 to 5 days. In addition, simulator training has become more and more sophisticated with the advent of virtual reality devices in the endovascular field. These simulators offer not just a chance to examine the competency of trainees without putting patients at risk, but also a significant opportunity to practice and develop technical skills at the trainee's own pace. The constant refinements of both software and hardware by simulator manufacturers have already resulted in many simulation systems that provide extremely realistic and practical training tool for endovascular interventions.

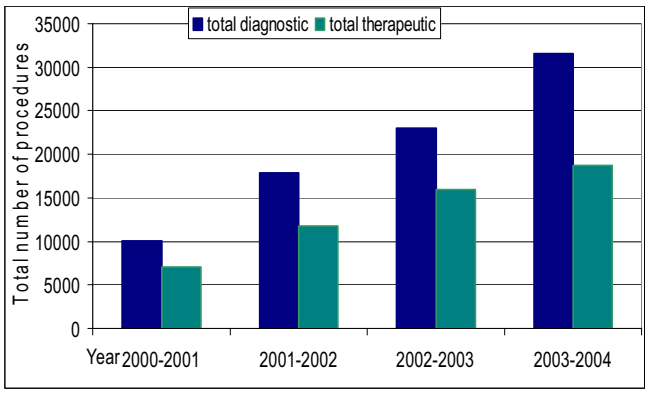

Figure 2 Total number of endovascular diagnostic and therapeutic procedures performed each year by vascular fellows during the period 2000-2004.

Have We Done Enough? A Last Word

Although long-term outcomes of many endovascular procedures are still not fully defined, the advantages of percutaneous interventions have been clearly demonstrated, especially in the aging population with multiple medical comorbidities. The increasing demands of our patient with vascular disease require that vascular surgeons incorporate catheter-based skills into their armamentarium and become fully competent in all aspects of endovascular care. Although tremendous progress has been made over the last decade, much remains to be achieved, particularly in the training of established practitioners and in the establishment of residency programs that provide outstanding training in the diagnosis and management of vascular disease in combination with a uniformly high volume of open and endovascular procedures. It is imperative for the vascular community to balance innovation, assessment, and training in its charge to lead the future of this field.

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