PRESIDENTIAL ADDRESS

From the Southern Association for Vascular Surgery

The aviation model of vascular surgery education

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First, let me express my gratitude to all of you for allowing me to serve as the President of the Southern Association for Vascular Surgery. Today, I will explore the state of vascular surgery education, including my personal view of the strengths and weaknesses. Then, I will review the aviation training model and, finally, offer a few thoughts on ways to improve vascular training. As we begin this journey, I would remind you that our education system is critical to our success as a specialty, and that each of us has a stake in the outcome.

What is the current state of vascular training? We must be doing something right! We are producing vascular surgeons with a skill set that is unmatched by other vascular specialists. We are leaders in minimally invasive endovascular procedures and masters of the most complex open operations. Further, there is growing interest in vascular surgery among medical students, especially women who now represent more than 30% of all vascular residents.[1] There are now 40 positions offered in 36 Accreditation Council of Graduate Medical Education (ACGME) approved integrated vascular residencies, (the so-called 0 + 5 programs), and an additional 16 programs are in the process of submitting applications.[2-4] Vascular surgery is now recognized as one of the most competitive residencies based on the percentage of positions filled by US medical school graduates along with dermatology, orthopedics, ear, nose, and throat, radiation oncology, plastic surgery, and thoracic surgery.[5]

The year 2012 will be a historic year in vascular surgery. This June, the first 0 + 5 trainee will complete an integrated vascular surgery residency. But what will these surgeons look like? Will they gain the core surgical skills traditionally mastered over 5 years in general surgery or will they be super-specialists dependent on consultants to provide comprehensive care, similar to urology or orthopedic surgery? Will the decrease in open abdominal surgery result in a generation of vascular surgeons with inadequate open operative skills?[6] If you believe that education consists entirely of emulation, in the "see one, do one, teach one" tradition, then what I have to say will be of little interest to you. I believe it is critical to ask if we have the best educational system for training the next generation of vascular surgeons, or are we wedded to the Halstedian apprenticeship model because that is all we have ever known? In order to improve, I have identified some of the potential areas of concern for vascular surgery educators (Table I).

Over the last few years, we have been inundated with articles in both the academic and lay press emphasizing the parallels between surgery and aviation.[7,8] In both cases, highly motivated, well-trained individuals undertake complex missions under potentially stressful conditions. But are the parallels between surgery and aviation really valid? To answer this question, I decided to learn more about aviation training and I will share with you a few of my thoughts.

I began my journey by phoning a friend. Admiral Patrick Walsh was the president of my high school class (Fig 1). After graduation from the Naval Academy, Pat went on to a distinguished career in Naval Aviation, including a tour as the slot pilot with the Blue Angels. He later served as a White House Fellow and is now the Commander of the Pacific Fleet, responsible for 180 ships, 2000 aircraft, 125,000 sailors, and a multibillion dollar budget (Fig 2). We discussed the training of high-performance fighter pilots. I have distilled these conversations into the following principles: (1) do the right thing all the time, (2) do not underestimate your capacity for excellence, (3) practice, practice, practice, (4) trust the people around you, and (5) take care of yourself. One of the primary goals of aviation training is to develop a habit of doing the right thing all the time so that fatigue, stress, or incoming missiles will not deter you. All of these principles seem relevant to surgical trainees. I visited Naval Air Station, Whiting Field, just outside of Pensacola, Florida, the "cradle of Naval aviation." Most Naval aviators pass through these gates on the way to receiving their wings, but the journey to the cockpit

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Table I. Potential areas of concern for vascular surgery educators

1. Limited access to medical students.
2. Imprecise selection process.
3. Inadequate preparation of medical students for patient care.
4. Stress, fatigue, and burnout.
5. Heterogeneity in program quality especially complex open surgery.
6. Lack of readiness for independent practice.
7. Limited availability of valid patient-specific high fidelity simulation.
8. Inadequate advanced technical skills training for surgeons in practice.
9. Complexity of modern surgical practice.
10. Shortage of vascular surgeons.

Fig 1. Admiral Patrick Walsh, Commander of the Pacific Fleet and former Blue Angel pilot.

begins long before primary flight school (PFS) with an arduous selection process.

APTITUDE TESTING AND SELECTION

Since World War II, in addition to academic records and letters of recommendation, prospective Naval aviators are also ranked by their performance on a specially-designed aviation aptitude test called the Aviation Selection Test Battery (ASTB). The ASTB is administered by the Naval Aerospace Medical Institute and includes subtests in mathematical skills, reading skills, mechanical comprehension, spatial apperception, as well as aviation and nautical information. The ASTB has been shown to be highly predictive of performance both in the classroom and the cockpit.[9] It has been estimated that the ASTB saves the Navy more than $30 million a year in the costs associated with training attrition (Personal communication, Lieutenant Brendan D. Cox, Aerospace Experimental Psychologist, Naval Aerospace Medical Institute, Pensacola, Fla, July 2011).

Aptitude testing in surgery has not met widespread acceptance, at least in part, due to concerns regarding the balance between innate abilities and learned skills.[10] Currently, surgery program directors rely almost exclusively on medical school transcripts, performance on standardized tests, and personal reference letters in the process of candidate selection. These metrics are often inaccurate predictors of future performance in the operating room. For example, Medical College Admission Test (MCAT) scores have been shown to have a negative correlation with later success in surgical residency.[11] On the other hand, Schueneman et al[12] showed that visuospatial organization, stress tolerance, and psychomotor abilities correlate positively with surgical performance. Sachdeva and Blair[13] have suggested that selection criteria might also include personal qualities such as introspection, inclination to critically assess one's strengths and weaknesses, the ability to function well in teams, and willingness to accept change. There is now evidence that innate psychomotor abilities positively predict both laparoscopic and endoscopic simulator performance.[14,15] In vascular surgery, it has been shown that innate visuospatial and psychomotor abilities accurately predict performance on a virtual reality endovascular simulator.[16] The Royal College of Surgeons in Ireland has recently begun to evaluate both basic surgical skills, including knot tying, suturing, and laparoscopic skills, as well as innate psychomotor, visuospatial, and perception abilities in all candidates for advanced surgical training.[17] Identification of aptitudes critical to vascular surgery would be beneficial both to students considering a career in vascular surgery and educators seeking to optimize educational pathways.[18] I believe there is a need for vascular surgeons to consider a more robust selection process that includes aptitude testing.

AVIATION PIPELINE

Once selected for aviation training, student naval aviators (SNAs) enter a highly regimented six-step process analogous to residency training consisting of (1) introductory flight screening (IFS), (2) aviation preflight indoctrination (API), (3) PFS, (4) specialty flight training, (5) fleet replacement squadron (FRS) training in a specific aircraft, and finally (6) advanced systems and tactics training such as the "Top Gun" school (Table II). This process takes approximately 5 to 7 years, comparable to residency and fellowship training in vascular surgery. The aviation pipeline is a carefully coordinated process that matches the intake of new aviation students with the projected need for future aviation assets. Unfortunately, this coordination is largely absent in graduate medical education.

INTRODUCTORY FLIGHT SCREENING

The first stage of Naval aviation training begins before the candidate ever reaches Pensacola. Pilot candidates are first enrolled in a civilian aviation school to log 15 to 25 hours in the cockpit and pass the Federal Aviation Administration private pilot written examination. This step was introduced in 2001 to screen candidates for basic aptitude and motivation and to identify physical conditions such as claustrophobia and motion sickness that may ultimately lead to dropouts.

Fig 2. The 1986 Blue Angel demonstration squadron.

Table II. Six-step program for aviation training vs vascular surgery

Step	*Aviation*	*Vascular surgery*
1	IFS	Medical student introduction (vascular rodeo>
2	API	Boot camps
3	PFS	Core surgery
4	Advanced flight training	Vascular specialty training
5	FRS	Chief residency
6	Top Gun	MOC

API, Aviation preflight indoctrination; *FRS,* fleet replacement squadron; *IFS,* introductory flight screening; *MOC,* maintenance of certification; *PFS,* primary flight school.

Although we should be reassured with the popularity of the 0 + 5 programs, I think it is important to recognize that the applicant pool represents <0.5% of the more than 18,000 US medical school graduates. We cannot afford to take these students for granted. Medical school offers limited opportunities for students to experience the excitement, challenges, and personal satisfaction of a vascular surgery career. Students who are assigned to a vascular rotation frequently spend most of their time performing rudimentary clerical services under the direction of a junior level resident. If we intend to attract the best students to vascular surgery, we must do a better job of exposing the appealing aspects of our specialty to students and letting them get their "hands on the stick." Opportunities that emphasize surgical skills, such as suturing laboratories and endovascular simulation, have been reported to be beneficial in attracting medical students to vascular surgery.[19,20] For the past 15 years, the Department of Surgery at the University of Arkansas has required all third year medical students to participate in a multimedia, hands-on modular laboratory affectionately called the "Vascular Rodeo," designed to introduce medical students to the core content of vascular surgery with emphasis on technical skills and endovascular advances. As one step toward improving our vascular education programs, I believe that we must redouble our efforts to invite the best students into the "cockpit" and encourage their active participation in surgery. There may be opportunities to partner with industry to expose early medical students to advanced endovascular devices, clearly one of the most exciting aspects of our specialty.

AVIATION PREFLIGHT INDOCTRINATION

The next stage is API. API is an intensive 6-week introduction to meteorology, engineering, aerodynamics, air navigation, aviation physiology, physical fitness, and water survival, including the "hello dunker," in which students in full gear must escape from a simulated helicopter water landing. The word indoctrination means more than simply teaching facts and figures. It means to inculcate a set of ideas or attitudes that will underlie future behavior. Student aviators are introduced to the culture of safety, the necessity of cooperation and teamwork, personal discipline, and the importance of doing the right thing regardless of the cost. SNAs are welcomed into the fraternity of Naval aviators and are reminded of the duties of the individual to the organization as a whole. After visiting this program, I was impressed by the overwhelming sense of pride that these student pilots demonstrate.

It is my opinion that the rise of vascular surgery as an independent surgical specialty has been the result of our sustained commitment to the comprehensive care of patients with vascular disease, rather than enslavement to a particular operation, technique, or device. It is our commitment to the primacy of the patient that will sustain us in the future. Vascular surgeons stand alone amongst their surgical peers as the ones to call when bleeding gets out of hand, when the tumor invades vital structures, or when the gunshot wound threatens life and limb. We are a special group of surgeons and our residents deserve to recognize that they are the "fighter pilots" of the surgical community: some of the most intelligent, skillful, and resourceful sur-

geons alive. We are competitive, independent and headstrong, calm under duress and self-assured, highly skilled, and committed to excellence; characteristics that are critical to decisive action in the heat of battle. We ignore our own needs for the sake of our patients and we pay a high price in physical and mental fatigue. Many of you are aware of the results of a survey conducted by the American College of Surgeons indicating that nearly 4 in 10 surgeons exhibit symptoms of burnout.[21] I believe we undervalue the importance of collegiality and common purpose, and that we need to acknowledge our personal needs and learn to better care for each other. We should welcome our new recruits into the family of vascular surgery and indoctrinate them in our core values. I would argue that the most important lesson of vascular surgery training is the commitment to doing the right thing all the time. Given the rapid pace of technological evolution, it is impossible to predict the tools that the next generation of vascular surgeons will use, but if guided by the principles of disciplined, selfless, and patient-centered care, vascular surgery will continue to prosper.

BOOT CAMP

In addition to a need for indoctrination in our core values, it has become increasingly clear that medical students are arriving at the door of residency inadequately prepared to handle the responsibilities of direct patient care.[21] In an attempt to prepare medical students for the direct care of patients, a few schools have experimented with Boot Camps analogous to the API program[22-25] These month-long boot camps are offered during the fourth year of medical school and offer training in basic surgical skills and procedures, as well as the management of common postoperative problems and emergencies. Boot camps provide an opportunity to establish the foundations on which future vascular training will be based and should be mandatory.

PRIMARY FLIGHT SCHOOL

The next stage in aviation training is PFS. PFS is based on a highly standardized syllabus that includes classroom courses, simulation, and flying. Progress in the pipeline is dependent on measured achievement rather than longevity and service. The primary flight syllabus takes a typical candidate approximately 6 months to complete.

PFS is comparable to core surgery training. Currently, the core surgery curriculum is defined by 24 months assigned to various nonvascular rotations. Programs vary widely in curriculum design and expectations of performance. Because the curriculum, as it currently exists, is not competency-based, there is no assurance that trainees will acquire the critical knowledge and skills that will serve as the foundation for a lifetime of patient care. In order to address these issues, the ACGME recently announced pilot projects in surgery, medicine, and pediatrics to identify specific measurable milestones for each level of training.[26] How these pilot projects will affect vascular surgery is as yet unknown. In my opinion, the core curriculum needs to be defined by specific, measurable competencies with promotion to advanced surgery dependent upon successful attainment of these milestones much like the aviation syllabus.

ADVANCED SPECIALTY TRAINING

After approximately 6 months in PFS, students enter the three main specialty pipelines: jets, propellers, or helicopters. In general, the higher performers enter the "strike" or jet pipeline. Strike students begin intermediate training in a generic "student" jet platform for a period of approximately 12 months, depending on the need for pilots and the availability of training resources. At the completion of the Tailhook syllabus, approximately 80% of these intermediate students are selected for advanced strike training, leading ultimately to tactical jets like the F/A-18 Super Hornet and the Joint Strike Fighter F-35 Lightning II. After this segment of training, the SNA is awarded "wings" signifying recognition as a Naval aviator.

A typical day in flight school begins with a detailed one-to-one preflight briefing based on a specified checklist. The student is expected to have reviewed the assignment for the day and be able to discuss the critical steps. In most cases, he or she will have practiced the assignment in a cockpit simulator with another student or instructor. He or she must be able to recite from memory specific emergency action items such as the response to an engine failure. Further, the student is required to report any personal physical or psychological problems that might interfere with successful completion of the mission. The mnemonic IMSAFE stands for illness, medication, stress, alcohol, fatigue, and emotion. There is a strict 12-hour "bottle to throttle rule" that means that the trainee is completely free from the effects of alcohol. The instructor may cancel the flight if the student is not fully prepared both mentally and physically for flying.

This act of formal self-assessment is largely absent in surgical training despite the multitude of human factors that should be considered before embarking on a complex surgical journey. One highly publicized recent report indicates that modest alcohol consumption in the evening may have lingering effects on the performance of laparoscopic skills as late as 4 PM the following day.[27] There is ample evidence that extreme fatigue is associated with deterioration in selected performance criteria.[28,29] It is the basis of universal flight crew rest rules. Based on similar logic, resident duty hour restrictions were enacted, in part, to reduce medical error by reducing fatigue. Unfortunately, there is little evidence that duty hour restrictions have been effective on either count: residents do not consistently report less fatigue (due in part to increased moonlighting) and surgical errors have not decreased.[30,31] In fact, the increase in the number of handoffs has had the perverse effect of increasing the rate of communication errors with subsequent consequences for patient care.[32] In the end, fatigue and stress are inevitable. An alternative strategy is to learn to recognize fatigue, mitigate its effects, and manage the consequences rather than by attempting to avoid fatigue through arcane regulation. But if we do not learn to do a better job of policing ourselves and acknowledging

that there are times when we would be better off to cancel a case than push forward in a state of physical or mental exhaustion, others will assume this responsibility in the name of patient safety. I am not suggesting that needed care be withheld because you have had a tough day, but we must learn that we are human, we have limits, and sometimes we are simply not "fit for flying."

PREOPERATIVE BRIEFING

James McGreevy, a pilot and surgical educator, has recommended that specific defined learning objectives be established before every operation.[33] Residents should be required to have prepared for elective procedures by completing appropriate reading, reviewing relevant anatomy, be able to describe the steps of the operation, and the management of common intraoperative emergencies. The time constraints imposed by the reality of patient care cannot be ignored. Flight instructors are not expected to teach student pilots with a plane load of paying passengers! But it should be built into the fabric of residency training that rarely should an operation be undertaken without an adequate preoperative briefing between the staff surgeon and resident, even if it only occurs at the scrub sink.

At the end of each flight, the instructor completes a detailed, objective assessment of the flight performance. The student and the instructor review the key lessons of the day, with emphasis on areas of improvement and attention to critical points of failure. Despite the evidence supporting proximate feedback in surgery, many surgical trainees complain that current evaluation methods are inadequate and inaccurate.[34] In the words of Lord Kelvin, "If you cannot measure it, you cannot improve it." Unfortunately, the development and validation of reliable tools for the objective assessment of surgical competence remains elusive. Despite widespread recognition as a pioneering effort, the Toronto Objective Structured Assessment of Technical Skills (OSATS), introduced in 1997, has not been widely adopted because of the expense, complex organization, and faculty time required for implementation.[35] Evaluation tools specific to vascular surgery have not yet been validated. Although endovascular simulators have the potential to provide mathematical and statistical feedback, the reliability and clinical relevance of these measures remain unproven.[36] As a start, I believe that we should develop a Basic Vascular Skills curriculum similar to the Fundamentals of Laparoscopic Surgery model. I propose that all residents attain a satisfactory performance to qualify for Board certification. A similar process could be used for recertification.

FLEET REPLACEMENT SQUADRON

Before the new pilot joins his first squadron, he or she is trained in the aircraft specific to that squadron, a process that occurs in the FRS. Before the introduction of this transitional phase of training in the 1960s, inexperienced pilots were often thrust into combat with dire consequences.

The FRS is similar to the Chief Resident year in which the trainee assumes near-complete responsibility for developing and executing complex treatment plans before entering practice. Unfortunately, surveys suggest that many finishing residents express doubts about their readiness for independent practice.[37] Although it is natural and probably reassuring that trainees acknowledge their limitations, there is concern that the Chief residency experience has been irreparably diminished by medico-legal and reimbursement issues. Furthermore, I suspect that some 0 + 5 residents will elect to pursue additional advanced training in the open treatment of thoracoabdominal aneurysms, or in branched and fenestrated endografts. One solution is to revive self-funded Super Chief positions that occur after completion of residency and beyond the reach of ACGME regulations prohibiting the trainee from billing for services.

VASCULAR SURGERY SIMULATION SUMMIT

Senior aviators are required to participate in an ongoing process of self-improvement that includes the use of multimillion dollar, high-fidelity, full flight simulators. Due to the enormous expense associated with live cockpit training, high-fidelity flight simulation is cost effective. For example, currently, about 12% of the FA-18 Super Hornet syllabus occurs in a flight simulator with a plan to increase to more than 40% over the next decade resulting in multibillion dollar savings across the entire range of military aviation.[38]

When the aviation model is invoked in the context of surgical education, most people immediately imagine sophisticated surgical simulators in which surgical trainees will rehearse an operation before undertaking the actual procedures, where accomplished surgeons can obtain deliberate practice much like musicians or athletes, and where recertification depends on the ability to manage emergencies in a simulated surgical "cockpit." Unfortunately, the promise of patient-specific, high-fidelity, virtual reality vascular surgical simulation remains largely unfulfilled due to the enormous development costs, and the computational complexity associated with mimicking the response of tissue to deformation.[39-41] Low-fidelity, low-cost simulation is effective for teaching basic surgical skills such as suturing and knot tying, or the sequence of steps in an operation to novice surgeons, but is remarkably ineffective for advanced learners where fidelity is critical. One of the obstacles to advancing the state of vascular surgery simulation is the absence of a forum dedicated to this purpose. To advance the development of vascular-specific simulation, I believe that we should establish a *Vascular Surgery Simulation Summit* devoted to academic progress in all aspects of vascular education, including curriculum development, open and endovascular models, assessment tools, and innovation.

TOP GUN

In addition to simulation training, senior aviators may qualify for advanced training opportunities such as Naval Strike and Air Warfare Center, the home of Top Gun. I had the privilege of visiting Naval Air Station Fallon as the guest of Rear Admiral John W. Miller. The base is located about an hour east of Reno in the high mountainous dessert of

northern Nevada. It is an ideal location for advanced strike training due to the remote location and varied terrain. I was surprised to find that the "Top Gun" school was developed as a response to a crisis in Naval aviation.

In 1968, the United States was losing the air war in the skies over North Vietnam despite technological superiority.[42] Introduced in 1960, the F-4 Phantom was the premier fighter in both the Navy and Air Force. At mach 2.2, it was faster than the Russian-made Migs and its air-to-air missiles had greater range. The missile capabilities were believed to be so effective that the conventional cannons were abandoned. Close range "dog fighting" was eliminated from the training syllabus and elevated to a punishable activity for Navy pilots. In assessing the reasons for the startling failure of American air power, Captain Frank Ault concluded, in a now famous report, that there was inadequate air-crew training in realistic air combat maneuvering.[43] In response, the Navy established the Advanced Fighter Weapons School at Miramar in Southern California in 1969 so pilots were able to experience realistic head-to-head air combat with instructors flying enemy planes. Within a short time, the Navy kill ratio in Vietnam reached an astounding 12:1 predominantly by improving training tactics. In discussions with the current faculty at Naval Strike and Air Warfare Center (NSAWC), it was emphasized that cockpit simulation alone is no substitute for realistic air combat maneuvering.

Currently, surgeons in practice seeking advanced skills training are faced with an ever-expanding, uncoordinated, and unregulated maze of symposia, industry-sponsored weekend courses, commercial workshops, congresses, and meetings. In an era of mandated life-long learning, we must simply do better to provide advanced skills training, free of commercial bias, to surgeons in practice.

BIRTH OF CHECKLISTS

Up until this point, I have focused primarily on individual performance. During the past few years, systems analysis suggests that surgical outcomes extend beyond the skills and judgments of individual surgeons to include interactions between members of the surgical team and the surgical environment (Fig 3). Aviation and safety are so closely intertwined that it is difficult to imagine one without the other. But that has not always been the case. During the first half of the 20th century, pilots resisted the kinds of standardization, checklists, and procedures that many surgeons find intrusive and distracting today.

The birth of checklists in aviation is traced to a crisp fall morning in Dayton, Ohio in 1935. In response to a request from the Army Air Corps for a bomber with improved payload and range, three planes competed in a "fly-off": (1) the Douglas DB-1, essentially a military version of the civilian model DC, (2) an upgraded version of the Martin B-10, the dominant bomber in the US inventory, and (3) the Boeing Model 299.[44] The four-engine Boeing was a much more powerful and, some said, unruly plane. On the morning of the test flight, Major Ployer Hill, one of the most respected test pilots of the era, guided the Boeing to a picture-perfect takeoff. Onlookers were silent as the plane ascended steeply to about 300 feet off the ground when it suddenly, and inexplicably, paused, banked abruptly, and crashed in a fireball. Two of the five crewmen died. The 299 was labeled a death-trap, too complicated to fly safely. In the analysis of the crash, investigators blamed the crew for forgetting to release a simple lock designed to protect the control surfaces from damage in strong winds. Hoping to avoid the fate of the Dayton crew, pilots at Langley assigned to continue testing the 299 began to make lists of everything they had to remember before takeoff. With the aid of a simple preflight checklist, the Model 299 went on to play a decisive role in World War I in the form of the B-17 Flying Fortress. Some historians have suggested that if the preflight checklist had not been developed, the outcome of World War II would be uncertain.

Fig 3. "Now don't be deceived, I'm making this look very easy." Copyright 2011, Andrew Evans, MD.

There is mounting evidence that standardization and checklists in surgery save lives.[45] The World Health Organization surgical checklist, developed by Gawande, has been shown to reduce mortality by 30% to 50% at virtually no cost.[46] Recently, the same group introduced a series of 12 "Crisis Checklists" that cover the most common surgical emergencies.[47] These checklists are not designed to replace skill, judgment, or innovation, but to make certain that uncommon but critical actions are performed. There is no substitute for experience in the cockpit or the operating room, but I believe that vascular surgery training could be improved by the development of standardized specialty-specific crisis checklists.

STERILE COCKPIT RULE

Recent publications have documented the startling number of interruptions and distractions that occur during the course of routine surgical procedures.[48,49] Disruptions have been shown to affect the quality of surgical care, a fact that surgeons are less willing to acknowledge in comparison to other members of the surgical team.[50,51] During the critical phases of an operation, the resident should be free from extraneous distractions, including questions regarding management of patients outside the operating room.

In aviation, commercial carriers enforce a so-called "sterile cockpit" rule during mission-critical phases such as below 10,000 feet, whereby extraneous conversation unrelated to the active process of flying is prohibited.[52] The process of invoking the "sterile cockpit rule" is public, explicit, and formalized to assure that all members of the team are aware it is in effect. We have considered installing the equivalent of an "on air" sign above the operating room door to alert all involved that surgery is underway and appropriate etiquette is required. When the sterile cockpit rule is in effect, we expect the operating team to remain intact, including the surgeons, the circulating nurse, the surgical scrub technician, and at least one member of the anesthesia team.

LIMITATIONS

I readily admit that vascular surgery is not flying. The human body is far more complex than even the most sophisticated flight deck. I have interviewed numerous surgeons who are pilots and not one believes that flying is more difficult than operating. In addition, the resources committed to aviation training dwarf the budget committed to surgical education. It is estimated that the Navy invests up to $9 million dollars in training each fighter pilot, whereas direct and indirect medical education costs for a vascular resident are approximately $675,000. The federal government is the primary source of funding for graduate medical education through supplementation of hospital reimbursement. Recent events threaten to drastically reduce graduate medical education (GME) funding at a time when shortages in the physician workforce, and particularly the surgical workforce, seem likely. In specific, the Medicare Payment Advisory Commission has stated that up to 50% of indirect GME reimbursement is not "empirically justified" by actual hospital costs associated with education. The Simpson-Bowles Deficit Reduction Commission has recommended a reduction in total GME funding of more than $60 billion over 10 years. It has been estimated that there will be a shortage of 750 to 1000 vascular surgeons over the next 20 years.[53] At first glance, it would seem that the addition of the 0 + 5 integrated residencies would be able to meet the demand. But in many institutions, the cap on residency positions at 1997 levels may force some programs, such as ours, to eliminate 5 + 2 positions. The net effect on the total number of vascular surgeons entering the workforce over the next few years remains uncertain but may threaten our ability to meet the needs of the growing geriatric population.

I conclude my remarks by affirming that the current state of vascular education is strong. But I believe that there are simple lessons that we can borrow from others in the business of educating high-stakes performers that can make us even stronger. As I review this list of recommendations, ask yourself how you can personally contribute to educating the next generation of vascular surgeons. In particular, I would make you aware of a new Society for Vascular Surgery initiative headed by Richard Cambria, MD, to expand the number of vascular training positions in places that have not traditionally been considered "academic" institutions. I encourage you to consider how you can make this effort successful.

The following items represent specific areas for improvement in vascular education:

1. Expand innovative educational opportunities, like the "Vascular Rodeo," for students to experience the excitement of vascular surgery.
2. Refine the selection process of vascular residents to include validated aptitude testing.
3. Require that all trainees participate in "Boot Camps" before residency to assure grounding in practical patient care skills and indoctrination into the traditions, values, and behaviors unique to our specialty.
4. Develop a vascular syllabus that is competency-based with measurable endpoints to assure that all vascular surgeons retain the core surgical skills to provide comprehensive care to the vascular patient.
5. Incorporate the processes of preoperative briefing, postoperative debriefing, and personal self-evaluation (IMSAFE) into the fabric of surgical training.
6. Expand the availability of specialty fellowships or "super chief" positions to ease the transition into independent practice.
7. Establish a *Vascular Surgery Simulation Summit* to advance the development of patient-specific virtual reality simulation.
8. Enhance opportunities for advanced skills training for surgeons in practice.
9. Encourage vascular surgeon leadership of a systems approach to surgical safety, including team training and the development of standardized emergency checklists.
10. Finally, increase the number of vascular training programs by 50% over the next 5 years.

The Southern Association for Vascular Surgery was founded on two core principles: advancing surgical education and encouraging collegiality. I believe that there is no greater privilege than to pass your knowledge and experience to the next generation for the benefit of others. I believe that our fraternity in this organization is vital to maintaining an exemplary standard of surgical care for our patients. I want to say again how much I appreciate the honor of serving as President for the past 12 months. It is

the highest honor of my life and I am deeply grateful to you all.

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