Incorporating simulation in vascular surgery education

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The traditional apprenticeship model introduced by Halsted of "learning by doing" may just not be valid in the modern practice of vascular surgery. The model is often criticized for being somewhat unstructured because a resident's experience is based on what comes through the "door." In an attempt to promote uniformity of training, multiple national organizations are currently delineating standard curricula for each trainee to govern the knowledge and cases required in a vascular residency. However, the outcomes are anything but uniform. This means that we graduate vascular specialists with a surprisingly wide spectrum of abilities. Use of simulation may benefit trainees in attaining a level of technical expertise that will benefit themselves and their patients. Furthermore, there is likely a need to establish a simulation-based certification process for graduating trainees to further ascertain minimum technical abilities. (J Vasc Surg 2010;52:1072-80.)

Current training paradigms have systematically focused on caseload to determine the adequacy of vascular training,[1,2] but is this really the metric we should be using to appraise our trainees? Vascular surgery is distinguished by being a low-volume/high-complexity specialty, where rigorous assessment of technical skill is vital. The traditional apprenticeship model introduced by Halsted of "learning by doing" may just not be valid in the modern practice of vascular surgery. The model is often criticized for being somewhat unstructured because a resident's experience is based on what comes through the "door." This paradigm is now further challenged by the reduction in trainee work hours and the shortening of time in residency. Following Ericsson's theorem of deliberate practice, expert performance in some fields has required up to 10,000 hours of rehearsal.[3] We conducted a fellow's contest at the Society for Clinical Vascular Surgery in 2009 and noted wide disparities in the fellows' ability to perform both a straightforward anastomosis (femoral anastomosis) and an endovascular procedure (renal artery stenting). The interesting aspect of this exercise was that a fellow who was below par on one task also performed poorly on the second task.[4] This is likely a combination of the training provided at individual institutions as well as a reflection of the trainees' individual abilities.

In an attempt to promote uniformity of training, multiple national organizations are currently delineating standard curricula[5,6] for each trainee to govern the knowledge and cases required in a vascular residency. However, the outcomes appear to be anything but uniform. This means that we are graduating vascular surgery specialists with a surprisingly wide spectrum of abilities, which in turn may alter the public's perception of the specialty. When we certify a fellow based on cases completed, does this really reflect the candidate's actual technical abilities? Is 2 years really sufficient time to learn the plethora of skills necessary to be the "complete" vascular surgeon, particularly when considering the constant expansion of endovascular and hybrid procedures? Considering this, does assisting on a distinct procedure, which in most fellowships may only show up once or twice a year, qualify a trainee to do one?

Surgeons are perpetually being evaluated, from their first days in medical school until they finally become attending physicians. As a surgeon progresses in training, it is expected that he or she will be able to gradually demonstrate greater knowledge of surgical practice, clinical acumen, and evidence-based, patient-specific decision making. As surgeons complete their training, we require that they maintain their professional growth, but at no point do we evaluate the technical surgical skills of these surgeons.[7] Maintenance of certification guidelines are evolving to address ongoing professional and technical development. The ability to provide specific skills training may permit trainees

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to learn in a controlled, safe setting, with the capacity for improving and assuring the quality of our trainees. This form of training is used in many surgical fields, but it is currently severely underused in vascular surgery in the United States.

In 2005, the American College of Surgeons (ACS) and the Association of Program Directors in Surgery (APDS) established the Surgical Skills Curriculum Task Force. The committee's task was to improve resident performance through skills practice and to use assessment of skills as a means of determining "operating room readiness."[5] The Fundamentals of Laparoscopic Surgery (FLS), which were developed by the Society of American Gastrointestinal and Endoscopic Surgeons (SAGES), are one of the most robust tools in surgical education. FLS has been amply validated[8] and is now a prerequisite in general surgical training programs. The ongoing development of a standardized curriculum and simulation guidelines by the Association of Program Directors in Surgery (APDVS) will add to the development of such structures in vascular surgery. One of the goals stated in the *To Err is Human* health care report (1999)[9] in the USA is a recommendation to fund researchers and organizations to develop, demonstrate, and evaluate new approaches to improving provider education in order to reduce errors.

The European Board of Vascular Surgery (EBVS) has embraced simulation as an assessment tool, probably out of necessity due to the broad training differences among the countries of the European Union. Qualification as a Vascular Surgeon by the European Board requires a demonstration of knowledge and cognitive ability coupled to a technical and endovascular skills assessment to evaluate the candidate's abilities. Although many may find it unrealistic to include a practical portion for certification purposes or may just resist the notion out of principal, all can agree that some use of simulation may benefit trainees in attaining a level of technical expertise that will benefit themselves and their patients. One could even propose continuing medical education (CME) courses, where surgeons could acquire, hone, or retrain skills. This paradigm would provide vascular surgeons in practice within the last decade access to accelerated endovascular training. These educational courses would permit vascular surgeons to maintain a higher level of training and promote uniformity.

As new training paradigms are being developed and assessed for vascular residents, evaluation of their abilities beyond a yearly computer-driven examination will become necessary. Simulator-based training and testing offers a crucial and standardized methodology to evaluate a trainee's proficiency. Introduction of the new training paradigms means that a number of vascular trainees will not have been filtered by general surgery programs, and thus, 5 clinical years of assessment and skill training will be absent. Limited work hours, increasing graduate medical education requirements and multiple other responsibilities dictate that a resident needs to be assessed not only for competency in endovascular procedures but also for open procedures. Thus, within these new training paradigms, standardized simulation curriculums approved by the Society for Vascular Surgery (SVS) that are able to evaluate the resident on a series of metrics must become integrated into the clinical and didactic education.[10]

Drs Panetta, Matsumoto, and White have described the guidelines for the curriculum in emerging technologies for the APDVS as follows:[11]

1. To understand the basic principles of emerging technologies in vascular and endovascular surgery.
2. To develop a working knowledge of the equipment, techniques, technical problems, troubleshooting, and recovery techniques.
3. To understand the physical properties of devices including but not limited to wires, catheters, balloons, coils, stents, stent-grafts, filters, and delivery systems.
4. To understand the physical properties, basic engineering and evolution of devices as they relate to their clinical applications, implantation, biocompatibility, tissue reactions and interactions, graft metallurgical interactions, wound healing, limitations, and overall use in the treatment of vascular disease.
5. To understand the indications, applications, complications, management and results of imaging modalities, basic techniques, newly developed techniques, and implantable devices used to treat vascular disease.

These are all elements in vascular education that continue to evolve due to emerging technologies and techniques. For the vascular trainee to remain well versed in these applications, he or she may find that there is a need to acquire skills not only during residency but also afterward as one enters practice. Simulation can provide such an opportunity on many levels.

DEFINITION OF MEDICAL SIMULATION

Medical simulation is defined as "a person, device, or set of conditions which attempts to present [education and] evaluation problems authentically." Different types of simulators exist, each with their particular role (Table I).[12,13] The student or trainee is required to respond to the problems as he or she would under natural circumstances. Frequently, the trainee receives performance feedback as if he or she were in the real situation.[14,15] One of the elemental questions remains: how much realism is actually necessary? Some of the characteristics, which are common to most simulation technologies, are:

- Cues and consequences that are very close to reality.
- Trainees can be placed in complex situations.
- The fidelity of a simulation is never completely akin to actual clinical conditions. Among other reasons, this stems from technologic limitations (eg, the endosimulator's inability to learn, reliability of haptics), costs, and ethics.
- Simulations can take many forms; for example, an inanimate model, such as an anatomic model, some can be computer models, such as endosimulators;

Table I. The spectrum of simulators and their characteristics[12]

Simulator type	*Applicable to vascular surgery*	*Simulator name*	*Automated responses*	*Performance feedback*	*Independent learning*	*Cost*
Part task trainers	Yes	Limbs & Things, Pontresina vascular course	No	No	Yes	Low
Computer programs	Yes	WebSet, other Web-based tools[13]	Yes	Yes	Yes	Low
VR/Haptic	Yes	Simbionix, Mentice, SimSuite	No	Yes	No	High
Simulated patient, environment	Yes	Orzone	No	Yes	No	Medium
Integrated simulator						
Model driven	Yes	METI simulator, SimMan	Yes	No	No	High
Instructor driven	Yes	SimMan	No	No	No	Medium

Table II. Percentage with which a teaching element relates to its ability to facilitate learning on high-fidelity simulators[17]

Variable	*Facilitation, %*
Feedback is provided during the simulation	47
Learners engage in repetitive practice	39
Simulation is integrated into an overall curriculum	25
Trainees learn with increasing task difficulty	14
Simulation is adaptable to multiple strategies	10
Clinical variation is incorporated into protocols	10
Simulation occurs in a controlled situation	9
Individualized learning is an option	9
Goals are clearly defined or measured	6
The scenario is akin to clinical practice	3

and some can be individual, whereas others are interactive.[15]

The Agency for Healthcare Research and Quality (AHRQ) report in 2007 essentially supports the effectiveness of simulation training "especially for psychomotor skills (eg, procedures . . .) and communication skills." This support is limited, however, by the rather weak data due to the small number of suitable trials and the lack of quantitative data.[16] A separate review performed by the Best Evidence Medical Education (BEME) collaboration also found that supportive literature was generally poor, not allowing for a quantitative analysis, but rather a more narrative and qualitative one. Their conclusion was that "the weight of the best available evidence suggests that high-fidelity medical simulations facilitate learning under the right conditions."[17] Along with this endorsement, the BEME listed 10 features that were found to be elements that led to effective learning based on the 109 articles included in their review (Table II).[17]

Using an endosimulator, Dayal et al[18] were able to demonstrate that novice interventionalists benefited from simulator instruction. Contrary to experienced interventionalists, novice users had a statistically significant improvement in their performance. There was a trend toward improvement for the experienced users, but this may have lacked statistical significance due to small numbers. The experienced interventionalists consistently performed better than the novice ones, which indicates that the system is valid and accurately reflects the skill of the user. These findings are consistent with much reported in the coaching literature, where novices show exponential gaining of abilities, whereas the experienced show plateau to low-level improvements based on practice alone. The authors concluded that these facts supported the validity of the simulator as an educational tool. In reality, this may be a quite simplistic evaluation of the model because the metrics that can be recorded today are much more sophisticated.

Two years later, Patel et al,[19] using the same simulator, were able to show a significant learning curve with improved performance for experienced interventionalists. They found that assessing technical skills with dynamic skill-related measures, such as catheter-handling errors, was a more dependable metric for use in high-stakes assessment of procedural performance over more basic metrics such as procedure time, fluoroscopy time, and contrast use, as evidenced by consistently high test-retest reliability measures. Furthermore, if one refers to the 10 features outlined in Table II, multiple facets are missing, including feedback as one of the most important elements. A study of virtual bronchoscopy found that the best simulation-based medical education was one where teachers were able to take full advantage of the educational tool and ensure curriculum integration. Furthermore, the report argued that the rate-limiting factor in simulation-based education was not the technology but rather the lack of well-prepared teachers and curriculum isolation.[20]

Ultimately, any simulator device can only be as good as the educational program in which it is rooted. Educators cannot allow the simulator technology to drive the agenda, but rather should be actively involved with the vendors to ensure that the simulators are developed to fill an educational need for a pertinent clinical situation.[12]

The Objective Structured Assessment of Technical Skill (OSATS)[21] is one of the most-used methods of trainee evaluation in vascular surgery and has been adopted by many surgical disciplines, in particular, by the leaders in vascular training at St. Mary's Hospital/Imperial College, London. This group took the evaluation beyond assessing basic surgical competencies to include procedure specific assessment. The procedure-specific Imperial College Evaluation of Procedure Specific Skill (ICEPS) rating scale for

Training Resources X Curricular Institutionalization X Trained Educators X Financial Support = Effective Simulation-based Healthcare Education

Fig 1. Equation depicts the necessary elements for effective simulation-based health care education.

assessing the content of a procedure uses a standard 5-point scale. Pandey et al[7] found a high interobserver reliability when using the ICEPS and OSATS, as well as the ability to discriminate between level of training.[7]

LIMITATIONS OF SIMULATION

Although certification of a training/simulation center is important to ensure quality, the ACS has, unfortunately, placed too little emphasis on the mentor/educator. The annual ACS course "Surgeons as Educators" attempts to bridge that gap with a curriculum that emphasizes acquiring or honing skills in curriculum development, teaching, performance, program evaluation, and program administration. The educator is undoubtedly the most crucial element of the simulation, without which the experience gained may be significantly hampered. In other words, a simulator or simulation is only as good as the person teaching.

McGaghie et al[22] developed an equation that appropriately delineates the elements that are necessary for successful simulation-based health care education (Fig. 1), but we believe there is a fourth element that is equally important, namely, financial support. The ability to generate any monetary support for such a center entirely hinges on the acceptance of this modality as a valid training tool by not only the institution but also physicians and industry. So we again circle back to the educator. There is, in general, no uniform manner or mechanism to educate, assess, or certify surgical instructors, and this is, of course, no different for simulation. Some courses are provided by the commercial vendors of the virtual simulators as well as some that are provided by schools and professional associations (as noted above), but these are not validated by any trustworthy data.[22]

In addition, if educators are to reach sound and valid decisions, judgments, or deductions about trainees, they need to have reliable data. Reliable data, which are obtained by outcome measurement research, are difficult to come by and often imperfect, and therefore this poses a great challenge in the advancement of effective simulation.[22] In so far as a valid set of tools are identified, then one must also identify the educational goals of that tool, because effective use of simulation also depends on a close match between tool and goal.[20] This may be a somewhat less complex task in vascular surgery because we are not talking about evaluating clinical competence but rather technical competence that allows for very narrow bandwidth of focused metrics in contrast to the evaluation of a broad and encompassing area such as effective medical practice. It is also unconsciously done by the attending every day in the operating room.

Other elements of simulation that remain controversial are skills acquisition and maintenance as well as transfer to practice. Several groups have estimated that skills acquisition does not deteriorate for 6 to 14 months,[23,24] whereas others have noted that significant skill decay is already evident at 3 to 6 months.[25,26] The reality is that little is known about skills acquisition and maintenance in vascular surgery. On the basis of the quoted literature and intuition, skill deterioration is likely to happen, particularly if one is testing complex tasks or procedures. One then returns to the very fundamental question, what is the goal of the simulation, education, or testing? Testing for certification has one principal goal, namely, to identify a fundamental ability in vascular surgery, much like FLS. One must assure that essential technical abilities are acquired, providing the trainee with the necessary skills to provide sound vascular endovascular and surgical care. The issue of skill deterioration is much more significant when one considers educating a trainee on potentially complex procedures or tasks that the trainee may not be performing frequently in clinical practice. This goes along with the fundamental principle of deliberate practice proposed by psychologist K. Anders Ericsson.[3]

The second point of controversy—transfer to practice—has not been evaluated appropriately in vascular surgery. A randomized, controlled double-blind study by Seymour et al[27] showed that laparoscopy skills developed in virtual reality simulators do transfer directly to improvements in the operating room. This has also been shown for more simple tasks such as central venous catheter placement.[28] A Cochrane Database Systematic Review also corroborates these findings.[29] The evidence is sparse because studies are often small, difficult to design, and are hard to conduct rigorously. Nevertheless, it is likely that some inference for vascular surgery can also be made from the studies.

SKILLS ACQUISITION IN A TIERED LEARNING ENVIRONMENT

In our center, we originally focused on endovascular training using high-fidelity simulation to gain basic wire skills and practice peripheral vascular procedures. We have since found that open skills acquisition is just as important, especially when considering strategies for conversion to open surgery after a failed endovascular procedure. Our training pathway was designed to cover the following three tiers of skills acquisition:

- Phase 1—Basic endovascular and suturing skills on inanimate, explanted tissue from porcine models.
- Phase 2—Advanced endovascular and surgical techniques and suturing skills on advanced simulators with pulsed flow to provide realistic feedback similar to actual clinical procedures.

- Phase 3—Exposure techniques in human cadaveric models.

The anatomy is not as critical in phases 1 and 2 because the emphasis is mainly based on the principles of vascular surgical techniques, both basic and advanced. In fact, it has been shown that training on a bench model transfers well to the human model, thereby supporting the use of bench (inanimate) models as the main training tool for training open surgical skills.[30] The human model does not provide any advantages as far as surgical technical skills are concerned, but we believe the cadaveric model is critical for the appreciation of advanced anatomic exposures, such as tibial and mesenteric vessels.

Given the lack of structured teaching protocols and lack of extensive "scientific" research in simulation, and in particular vascular surgery simulation, it is very difficult to put time requirements on trainee simulation sessions. Gurusamy et al[29] assessed learning curves for novices and expert surgeons on a virtual laparoscopic trainer. Novices plateaued at a median of seven repetitions, whereas expert surgeons demonstrated a learning rate at a median of two repetitions. Performance differed slightly for a different task with a learning curve, which plateaued at four repetitions. As good as this study is, it is hard to determine whether these data directly correlate with performance on vascular surgery simulators. Anastakis et al[30] found that 4 hours of training was probably insufficient to learn surgical tasks appropriately on models.

The ACS and the APDS have initiated the development of a comprehensive surgical skills curriculum three phases. The first phase includes 20 basic surgical skills tasks applicable to surgical trainees in all specialties. These modules cover basic surgical skills such as knot tying, suturing, airway management, chest tubes, and central lines, as well as basic and advanced laparoscopic skills and vascular and gastrointestinal anastomosis. Phase II includes full operative procedures that either include a significant technical component or are rarely performed during residency training but are considered vital for preparing the resident for surgical practice. These modules include procedures such as laparoscopic repair of inguinal and ventral hernias, laparoscopic and open colon resections, thyroidectomy, parathyroidectomy, and procedures for peptic ulcer disease and gastric resection. Phase III of the curriculum is focused on team-based training, incorporating essential team-based skills such as communication, leadership, briefing and planning, resource management, seeking advice and feedback, coping with stress, decision making and global awareness.[31]

The incorporation of both endovascular and surgical simulation in vascular education can follow the same basic principles listed above in three phases. Over the 2 years of a trainees' tenure during fellowship, one should ensure acquisition of basic surgical and endovascular skills (phase I), advanced endovascular and surgical skills (phase II), and appreciation of anatomic exposures. Every week, 2 hours of simulation/instruction should be provided to the trainee. Much like there is a requirement for didactics to elaborate on disease in all vascular beds, so is there a need to simulate training in all vascular beds. Modules can be constructed as such (Table III).

Training of specific techniques outside of vascular surgical fellowship/residency can be handled by short 2- to 3-day intensive hands-on and didactic courses. This has been shown to be an efficient way of training or retraining techniques.[32]

CENTER DEVELOPMENT

One of the many questions that arise when discussing simulation technology and its application in vascular training is how to develop a training center. This most commonly is defined as a room or area within the hospital where residents and fellows can practice on simulators to expand on skills they are taught in the operating room. This may or may not be supervised. Although several centers around the country house relatively small simulation centers or skills laboratories, very few centers of substantial size have been developed without significant industry or philanthropic support. Most educational centers have been built around education in laparoscopic surgery and typically do not focus on vascular surgery training needs, especially with regard to endovascular procedures. Furthermore, the acquisition of an endovascular simulator is even less common in the typical training program due to the expense.

Building a simulation center is a challenging task. A training program can be as simple as a simulator located in a small room, but how does that provide any educational value or growth potential? There are several things to consider when building a simulation center, and a mission statement can provide goals to target during the development process. Will the program need to serve residents and fellows or will it be available to all health care providers working with endovascular therapies, both in-house and beyond? Once learning groups (nursing, allied health, physicians) have been identified, educational objectives should be established to foster learning goals. Ultimately, the ability to provide a "zero fault" environment where learners can make mistakes and learn from these errors without clinical repercussions is critical. With this in mind, initial center development will rely on several key factors. Below are just a few to consider:

- Real estate within the hospital (location of space with proximity to clinical areas)
- Architectural considerations of the space (realism in the learning environment)
- Audiovisual recording capability (for debriefing after simulations)
- Conference room space in addition to the simulation suite (for prebriefing and debriefing with learners or teams)
- Managed access to space (security of space and a record of users)
- Clinical educator, faculty availability, and/or support staff

Table III. Proposed training modules for vascular trainees

Phase	*Vascular bed*	*Endovascular*	*Surgical*
Phase I		Catheters/wires/basic handling techniques	Anastomotic techniques (parachute, single running suture, etc)
		Ultrasound access	Endarterectomy
		Angiographic interpretation/IVUS	Vessel splicing
		Use of x-ray units	Patch/bypass techniques
		Percutaneous thrombectomy/lysis	Fasciotomy
Phase II	Extracerebral	Catheters/wires/approaches/stents	Carotid endarterectomy (including eversion)
	Upper extremity	Catheters/wires/approaches/stents	. . .
	Thoracic/abdominal aorta	Catheters/wires/approaches/stents	Thoracoabdominal, transperitoneal, retroperitoneal
	Visceral/renal	Catheters/wires/approaches/stents	Visceral and renal bypass (antegrade/retrograde)
	Aortoiliac	Catheters/wires/approaches/stents	Bypass/endarterectomy
	Lower extremity occlusive disease	Catheters/wires/approaches/stents	Bypass/endarterectomy
	Venous	Catheters/wires/approaches/stents	Phlebectomy
	Arteriovenous access	Catheters/wires/approaches/stents	Fistula/graft
	New devices/technology	Catheters/wires/approaches/stents	Grafts/instrumentation
Phase III	Extracerebral	. . .	Surgical exposure
	Upper extremity	. . .	Surgical exposure
	Thoracic/abdominal aorta	. . .	Surgical exposure
	Visceral/renal	. . .	Surgical exposure
	Aortoiliac	. . .	Surgical exposure
	Lower extremity occlusive disease	. . .	Surgical exposure

IVUS, Intravascular ultrasound.

- Curriculum development and evaluation
- Simulator(s) and courseware
- Recurring revenue (or financial support)

These points only cover a few considerations during center development and are in no way the only topics to consider. Initial investment in an endovascular simulator with a service contract (to keep the system functional and courseware up to date) and associated supplies can cost upwards of $300,000 to $400,000. A full-time technician or clinical educator can cost between $80,000 and $150,000 annually. Once a suitable space has been acquired, renovations and video recording capabilities should also be considered to allow for creation of the simulated environment and the ability to have postsimulation debriefing sessions to review the trainees' work. Providing the "look and feel" of real clinical space is helpful in a simulated suite to provide an atmosphere that can resemble the actual work environment.

Use of the simulator is probably the single most important priority. With all of the money and effort spent to get a program started, it will all be for naught without learners. These learners can be beginners (medical students, residents, and fellows) or advanced users (attending physicians) wanting to hone their skills before a challenging procedure. The airline industry has been at the forefront of simulator technology for training and maintaining pilot skills for years. It has done an excellent job of using simulation for all learner groups, including those learning to fly, those becoming familiar with a new aircraft, or those pilots being tested for emergency preparedness.

Simulators can be used for preprocedural planning, skills acquisition, device training, and maintenance of skills across an array of learner groups. Considering this, a full-time clinical educator is critical to the success of the program. The educator is someone who can manage the day-to-day operation of the simulator but can also facilitate training courses and work with physician champions to develop modules and scenarios. Trying to find the right person to serve in this role can be a challenge. Some of the simulation device companies will provide an on-site educator to facilitate training, but that is typically where their job ends. They do not seek out new users or work with faculty to develop new courseware without additional fees being charged to the hospital. Although this can be a challenge, the right educator can expand simulator usage with the overall goal of increasing patient safety and provider skills, while decreasing fluoroscopy time and morbidity and mortality associated with endovascular procedures.

Without a doubt, center development is a financially significant decision that has to be made by the hospital administration or the medical school, or both. There are surely many simulators around the country that are collecting dust in back closets because they were purchased with great vision to develop a training center but never reached their potential due to many of the limitations listed in this section. A physician champion that is compensated for his

Table IV. Description of courses run at Methodist Institute for Technology Innovation and Education (MITIE)

Medical specialty	*Laboratory description*
General surgery	SAGES fellows courses, NOTES, labs, surgical endoscopy courses, robotic courses, SILS courses, TMH foregut conference
Colorectal surgery	Robotic courses, SILS labs
Cardiac surgery	Re-Evolution Summit, fellows boot camp, robotic courses
Vascular surgery	Endovascular simulation courses, fellows boot camp, robotic labs
Cardiology	Endovascular simulation courses, endovascular robotic labs
Thoracic surgery	Lobectomy courses, VATS courses, endoluminal bronchial therapies course, robotic courses
Gastroenterology	Esophageal cancer courses, endoluminal esophageal therapies courses
Neurosurgery	MIS spine courses with various industry sponsors
Orthopedic surgery	Total hip courses, total knee courses, R&D labs
Emergency medicine	Simulated D2B drill with Houston Fire Department and TMH ED/cath lab
Nursing	New employee training, core competency validation, emergency patient condition, critical care courses
Internal medicine	Resident boot camp, FCCS courses, ACLS
Gynecology	Robotic courses, SILS/MIS courses
Oral and maxillofacial surgery	Oral and maxillofacial surgery labs
Urology	Robotic courses, R&D labs, laser prostatectomy courses, MIS courses, SILS labs

ACLS, Advanced cardiac life support; *D2B,* door to balloon; *ED,* emergency department; *FCCS,* fundamentals of critical care support; *MIS,* minimally invasive surgery; *NOTES,* natural orifice transluminal endoscopic surgery; *R&D,* research and development; *SAGES,* Society of American Gastrointestinal and Endoscopic Surgery; *SILS,* single-incision laparoscopic surgery; *TMH,* The Methodist Hospital; *VATS,* video assisted thoracic surgery.

or her involvement in developing a simulation program and continuing support can help to foster a successful program. Those programs that succeed have this type of clinical support and believe in the validity of simulation as a learning pathway. An example of the development of a dedicated educational center is the Methodist Institute for Technology, Innovation and Education (MITIE).

MITIE was born from the vision of its Executive Director, Dr Barbara Bass, a former Chair of the Board of Regents for the American College of Surgeons and President of the American Board of Surgery. The mission is to serve as an educational resource for practicing health care professionals seeking to maintain excellent clinical skills and acquire new ones. Like many other training facilities, it is intended to improve patient safety through these educational pursuits and conduct research on skills acquisition and technological development. Since 2007, MITIE has trained more than 2500 health care professionals from all over the world across 16 different specialties (Table IV). It became an ACS Accredited Education Institute in June 2008.

The American Board of Internal Medicine (ABIM) has also introduced an opportunity for interventional cardiology diplomates to earn credits toward the attainment of the 100 points required for Maintenance of Certification by the Self-Evaluation of Medical Knowledge. MITIE, in collaboration with SimSuite (Medical Simulation Corp), is one of the sites for accreditation. The aim is to mirror cases that would be encountered in daily practice, and this is the first time ABIM has used simulation to assess the competence of a physician. Physicians complete the "Interventional Cardiology Simulations" on-site at one of Medical Simulation Corporation's six SimSuite education centers. Although aimed at practicing professionals, the availability of this resource has attracted a full complement of nursing education modules, as well as subspecialty modules in diagnosis, laparoscopy, microsurgery, robotics, team building, and disaster management.

The development of vascular surgery now includes inanimate trainers (Limbs & Things Ltd and Pontresina European Vascular Training Course), as well as multiple endosimulators (Simbionix and SimSuite). We will develop multiple focused courses for all levels of trainees. The immediate weakness we have identified is satisfactory course curricula, and as such, we are now acting as a beta testing center to develop these simulator protocols. The ongoing curriculum development within the APDVS will enhance these efforts. Once the marriage of curriculum with course work and facilities is complete, we would, together with the cooperation of several large centers around the country, aim to develop a national curriculum consensus to offer comprehensive vascular training locally, regionally, and nationally and hopefully stimulate growth in this domain.

POTENTIAL IMPLICATIONS FOR THE SVS

A shift to simulation will ultimately require mandatory adoption. This may be society driven or mandated by regulatory and health care agencies (insurance companies, credentialing authorities, and government agencies). These same bodies will also need to provide adequate incentives, financial support, and mandates to fulfill the requirements. Some of these certification standards are already finding their way among a group of societies, including The American College of Surgeons, American Society of Anesthesiologists, Society of American Gastrointestinal and Endoscopic Surgeons, and Society for Simulation in Healthcare.

In a process that will need to go through phases of validation, we are of the opinion that it is imperative that the SVS proceeds toward developing criteria to stimulate the establishment of regional and national training centers, which have the ability to provide quality vascular education,

Table V. Distribution of training and certifying centers

Variables	*Training*	*Certification*
SVS accredited education institutes	No	Yes
Location	Local	National
Educators	Institutional	National
Educational objectives	ABS RRC mandated	ABS RRC mandated
Organization	APDVS	SVS-ABS-RRC
Provided at national/regional meetings	Yes	No

ABS, American Board of Surgery; *APDVS,* Association of Program Directors in Vascular Surgery; *RRC,* Residency Review Committee; *SVS,* Society for Vascular Surgery.

thus reducing costs for individual programs and promoting an increasing standardization of the specialty. We propose the support of centers for both education and certification (Table V). The goal of each training facility is very different, as would be the infrastructure. The testing centers would need to provide adequate facilities to accommodate trainees from all training programs, while locally all institutions would be mandated to provide simulation training as delineated by ABS, RRC, and SVS.

One does not necessarily need to "reinvent the wheel," but rather can adopt many of the features of simulator training already in use in Europe, such as OSATS and ICEPS. Within our framework, one can then identify the procedures or techniques that constitute minimal educational requirements for the SVS. Initial steps should include putting vascular residents from a variety of programs through multiple sessions and evaluating their performance improvement. Once the merit of the program is solidified, then there can be a gradual progression toward a certification process for new graduates, on not only the standard knowledge-based examinations but also a practical examination. In light of intense scrutiny of surgical performance by multiple governmental regulatory groups, it behooves us as a specialty to make the greatest efforts possible to ensure we are certifying not only bright surgeons but also technically competent ones.

Of course, the other significant element that will affect the implementation of simulation is cost. The Advanced Medical Technology Association and the Sunshine Act are likely to affect the ability of industry to directly support this endeavor, but the funds can be supported in part by industry in the form of educational grants. These grants would be managed centrally by the SVS, thereby assuring that all trainees have access to the mandated training.

CONCLUSION

We are not proposing that simulation should replace the interactions that currently exist in clinical practice, but rather that it is an indispensable tool that can potentially change and enhance medical education in vascular surgery, leading to an emphasis on skills acquisition and maintenance. Ultimately, establishing such elements can lead to uniformity in training and solidify vascular surgery education. What does it take for institutions to commit themselves to take that first step toward curricular adoption of simulation? It takes a few creative thinkers to see the benefits of simulation and to strive to fully integrate it into the facility and affiliated training programs. The certification process is a formidable way of recognizing those efforts. The ACS has appreciated this and currently has a certification process. The accredited institution then has the obligation to ensure achievement of clinical competence and development of expertise using the simulation tools available such as bench models, simulations, simulators, and virtual reality.

Beyond facility certification, faculty education is paramount and should stimulate insightful exploration. Research in simulation from a technology and educational perspective is rapidly advancing, and many simulation centers purchase or develop simulators for training and research purposes. Modeling, motor learning, curriculum integration, and performance quantification are some of the research areas of interest. We believe that the successful simulation centers are those that are involved in all facets of simulation.

AUTHOR CONTRIBUTIONS

Conception and design: JB, MD
Analysis and interpretation: ABL, EKP
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Writing the article: JB, MD
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